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Proceedings: Bureau of Mines Technology Transfer Symposium, Charleston, WV, June 23, 1983

Compiled by William W. Aljoe

UNITED STATES DEPARTMENT OF THE INTERIOR

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CONTENTS

UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

ft	foot	lb/ft^2	pound per square foot
ft/min	foot per minute	pct	percent
gal	gallon	psi	pound per square inch
in	inch	s	second
lb	pound	yr	year

AUTOMATED TEMPORARY ROOF SUPPORT (ATRS) SYSTEMS FOR ROOF BOLTING MACHINES

Proceedings: Bureau of Mines Technology Transfer Symposium, Charleston, WV, June 23, 1983

Compiled by William W. Aljoe[1]

ABSTRACT

This publication contains 10 papers presented at a symposium on ATRS systems in Charleston, WV, on June 23, 1983. Included are papers by MSHA Technical Support (Roof Control), West Virginia Institute of Technology, the Bureau of Mines, and seven roof bolter manufacturers and/or designers of ATRS systems. These papers summarize the most recent developments in ATRS technology and can serve as a guide to potential designers, developers, and users of ATRS systems.

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IMPROVED ROOF CONTROL SAFETY WITH ATRS SYSTEMS

By M. Terry Hoch[1] and William J. Debevec[2]

The collapse of mine roof has always been a major safety problem confronting the mining industry. Historically, roof falls have caused the death of more coal miners than the combined total of all other types of accidents. From 1906 through 1980, 85,026 lives were claimed in coal mine underground workings. Roof falls were responsible for 44,628 of these deaths, or 52 pct of the fatalities on record. However, as can be seen in figure 1, roof fall fatalities have exhibited a downward trend. This graph was formulated by taking 10-yr increments from 1910-19 through 1970-79, averaging the roof fall fatalities occurring in those years, and plotting them chronologically. Although the number of miners working in underground bituminous mines, and therefore the number of hours worked, has decreased in these years, the percentage reduction in workers and worker-hours is far less than the percentage reduction in roof fall fatalities.

Accident statistics are often deceiving unless normalized with exposure times. The following material is intended to place accident information into perspective. Figure 2 compares the tons mined, the worker-hours involved, and the roof fall fatalities for 1970 through 1982. All of these statistics were received from the Mine Safety and Health

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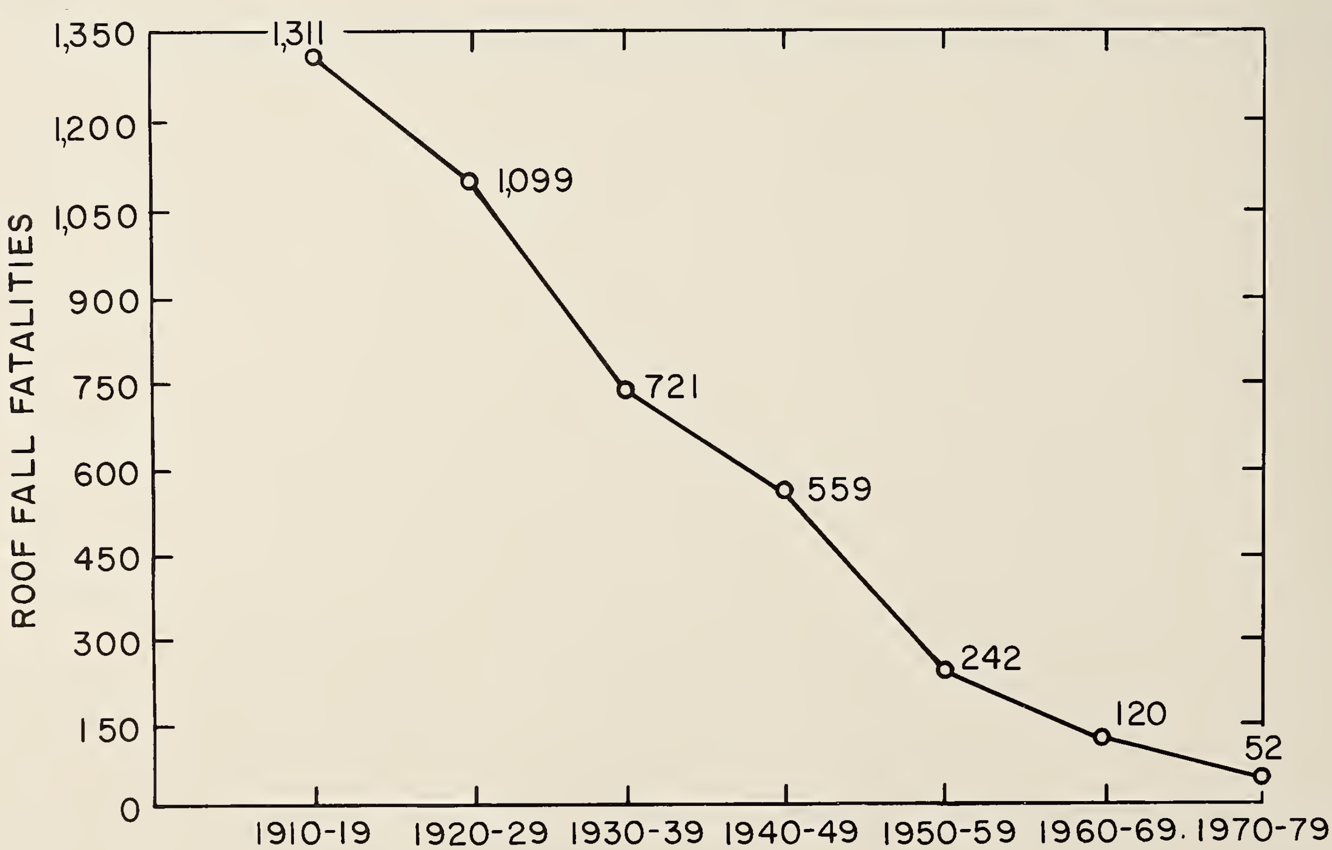

FIGURE 1. - Roof fall fatalities - 10-yr average.

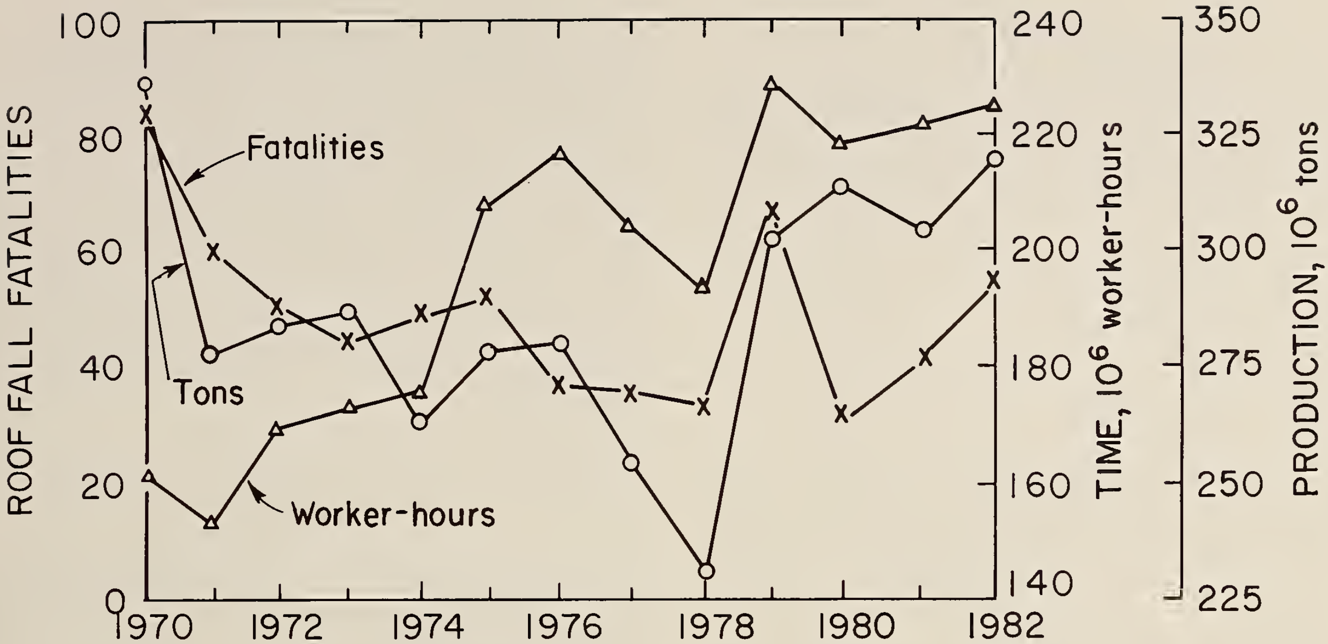

FIGURE 2. - Frequency curves.

Administration (MSHA) Health and Safety Analysis Center (HSAC) in Denver, CO, and pertain only to underground bituminous coal mines. A high of 84 fatalities was registered in 1970 and a low of 31 in 1980. The 1970 high of 337.9 million tons has not been surpassed, although the 1982 total of 320.9 million tons represents the second highest mark in this 13-yr study. The drastic decrease in tonnage for 1977 and 1978 was due to work stoppages. (Note that the baseline of the graph represents 225 million tons.) Worker-hours have followed a definite upward trend with a leveling off in the past few years. Since 1970, an increase of approximately 40 pct in total worker-hours can be seen. With the increase in hours worked and the general decrease in roof fall fatalities over the past 13 yr, a correlation exists suggesting that significant safety advances have been made that protect miners from the No. 1 underground hazard - roof falls.

This paper discusses one of these advances that MSHA believes to be a major contributor to this reduction in roof fall fatalities and that has a tremendous potential for further decreasing fatalities and injuries in the years to come. This advance is the use of automated temporary roof support (ATRS) systems, which provide protection from roof falls and are remotely set from beneath permanently supported roof.

1979-81 ROOF FALL FATALITIES: GENERAL OBSERVATIONS

As a means of justifying our beliefs, let us first take a close look at the roof fall fatality records for 1979, 1980, and 1981. The reason for focusing on these years is because a sufficient description of the statistics is available and the use of ATRS systems was beginning to accelerate during these years. It is estimated that machines equipped with ATRS systems increased from approximately 1,500 in 1979 to approximately 2,500 by June 1, 1983.

Table 1 summarizes the roof fall fatalities that occurred in 1979, 1980, and 1981. The total number of fatalities for all types of accidents in underground bituminous mines respectively was 105, 94, and 112, and the total number of roof fall fatalities in these years was 65,

TABLE 1. - Summary of roof fall fatalities[1]

Fatalities	1979	1980	1981
Underground bituminous (total)	105	94	112
Roof fall	65	32	41
Roof fall (inby supports)	52	22	24
Percent of roof fall fatalities (inby supports)	80	69	59

[1]HSAC statistics.

32, and 41. A breakdown of these roof fall fatalities was made by HSAC, and it revealed that a large percentage has occurred inby permanent supports. Table 1 illustrates that in 1979, 1980, and 1981 there were respectively 52, 22, and 24 roof fall fatalities inby supports. Although this number is unacceptably high, the percentage of roof fall fatalities that have occurred inby supports with respect to total roof fatals has progressively decreased in this 3-yr period. These figures imply that ATRS systems are reducing the percentage of roof fall fatalities occurring inby supports. Also, significant reductions in the total number of fatalities can be assumed as more and more mines convert to ATRS systems from manually set temporary supports.

Additional statistics that justify this belief are expressed in table 2. This figure illustrates the number of roof fall fatalities that are directly associated with manual setting of temporary supports. This activity is listed as "setting, removing, or preparing posts" by HSAC. With an ATRS system, this activity would virtually be eliminated and would reduce the amount of exposure time in which miners would be inby supports. As the figures show in table 2, the percentage of fatals related to manually set temporary supports compared with total roof fall fatals in any year has been decreasing.

TABLE 2. - Fatality data on manually set temporary supports

Fatalities	1979	1980	1981
Setting, removing, or preparing posts	20	7	8
Total roof fall	65	32	41
Percent of total	31	22	20

The point to be brought out by these statistics is that no matter what year is viewed, the results are the same; the occupations that require men to work in close proximity to the unsupported face are the high-fatality-frequency jobs. Assuming that the miners were well trained in roof control techniques, it can be implied that a reduction in accidents can be achieved by technological advances and by reducing or eliminating the amount of exposure time spent in unsupported areas through the use of automated temporary roof support.

ATRS IN LIEU OF CANOPIES

The ATRS systems presently in use are an integral part of the roof bolting machines or continuous miners equipped with integral bolters. They are designed so they can be set in the unsupported area from a remote position under permanent support. As the name implies, they are automated and therefore provide a positive support to the mine roof and eliminate the human error involved in setting conventional temporary support.

MSHA, through the Roof Control Division of the Bruceton Safety Technology Center in cooperation with our enforcement personnel, has pioneered the development of ATRS systems for the past 10 yr. Working with mining companies, machine manufacturers, union representatives, State agencies, and independent jobbers has produced safe, functional designs. In fact, the design of ATRS systems has been perfected so that in many mines they are accepted in lieu of canopies over the drilling controls of roof bolters and continuous miners with integral bolters. To be approved for use in lieu of canopies, the system must provide equal or greater protection from roof falls to the operator as required in CFR 75.1710-1(f).

The first "in-lieu-of" approval was granted in 1976, and since then 191 approvals have been issued. They involve 301 mines and approximately 2,000 machines. An additional 500 machines in the field have an ATRS with a canopy, which precludes the necessity for an "in-lieu-of" approval. Experience with machines currently equipped with ATRS systems shows that mine operators are realizing a substantial reduction in accidents caused by falls of mine roof during the roof bolting cycle. In addition, the use of these systems has resulted in the reduction of both face bolting time and the manual workload for roof bolter operators and helpers.

Currently, there is some confusion between approval of an ATRS system to replace manual setting of temporary supports and approval for use in lieu of canopies. Figure 3 illustrates the difference. For a mining company to gain approval to use an ATRS system to replace manual setting of temporary supports, the company must submit an application through the local MSHA district manager. Acceptance is conditional, depending on a variety of mining circumstances. On the other hand, if the machine does not provide a substantial canopy, the ATRS system may be accepted for use in lieu of a canopy over the drilling controls, but approval must be granted by the Chief of MSHA's Bruceton Safety Technology Center, through the Director of Technical Support.

Based on past performance and in-mine investigations, the following general criteria have been established to determine the acceptability of ATRS systems for either approval:

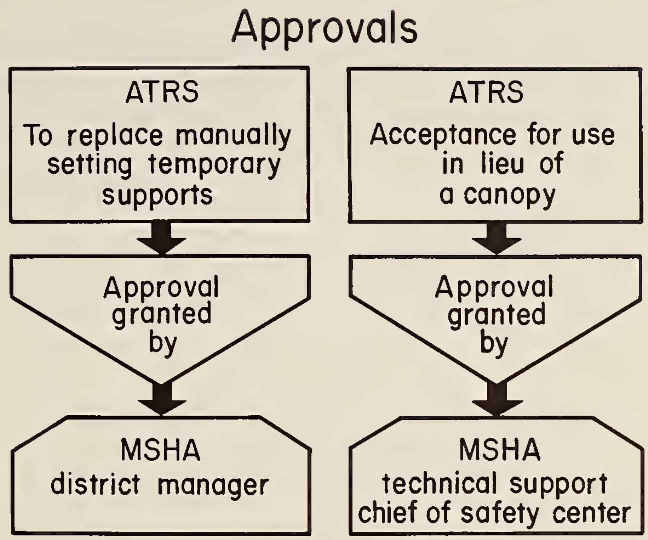

FIGURE 3. - Approvals.

1. The necessary ATRS system controls should be located so that they can be operated from under permanent supports.

2. The ATRS system should be firmly placed against the roof before advancing inby permanent supports.

3. All ATRS system hydraulic jacks should have check valves.

4. The ATRS system should be certified by a registered, professional engineer to withstand a prescribed load. This load is dependent on the intended work area.

5. The distance between the ATRS system and the coal face, rib, or permanent or temporary supports should be not greater than 5 ft.

6. Inch tram speed should be limited to a maximum of 80 ft/min.

GENERAL DESCRIPTION OF ATRS TYPES

Current ATRS systems consist of either a bar-type or safety-arm-type support for roof bolting machines and hydraulic jacks equipped with roof contact pads for continuous miners with integral bolters. Each has advantages and disadvantages depending on the specific application, but in general, they all perform the basic function of providing temporary support while the roof is being bolted.

Shown in figure 4 is a side view of the safety-arm type. It was developed to provide temporary roof support in the

immediate area of the roof bolt being installed. This type consists of a pair of steel arms mounted on each drill boom with a support structure attached to the top end. The support structures, which are of various sizes and configurations, are pressurized against the mine roof from a remote position by means of hydraulic elevating cylinders that rest directly on the mine floor. With the safety-arm type, the ATRS system must be repositioned remotely for each bolt to be installed.

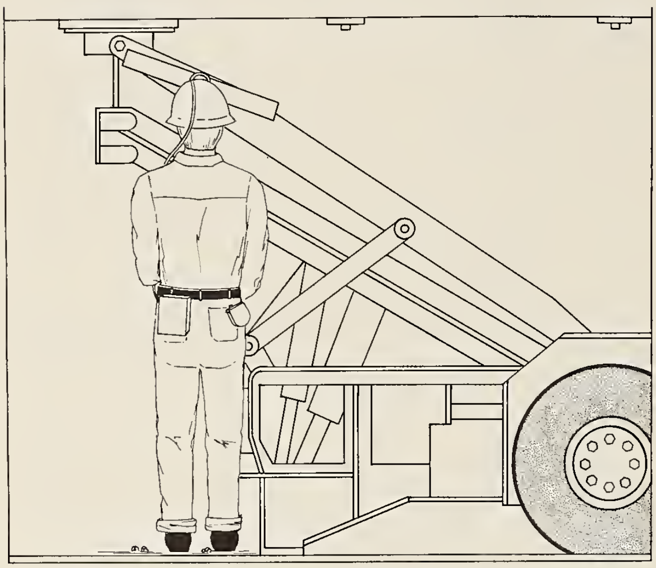

FIGURE 4. - Safety-arm-type ATRS system.

Figure 5 displays a single-bar system. The bar-type ATRS usually consists of either one or two bars equipped with roof contact pads mounted atop a hydraulic jack that can be pressurized against the mine roof from under permanently supported roof. This system is generally attached to a dual-boom roof bolter.

Dual-boom roof bolting machines are generally easier to equip with an ATRS system than single-boom, fixed-head "squirmer-type" machines. The lack of an operator's compartment and the location of the drilling controls at the front

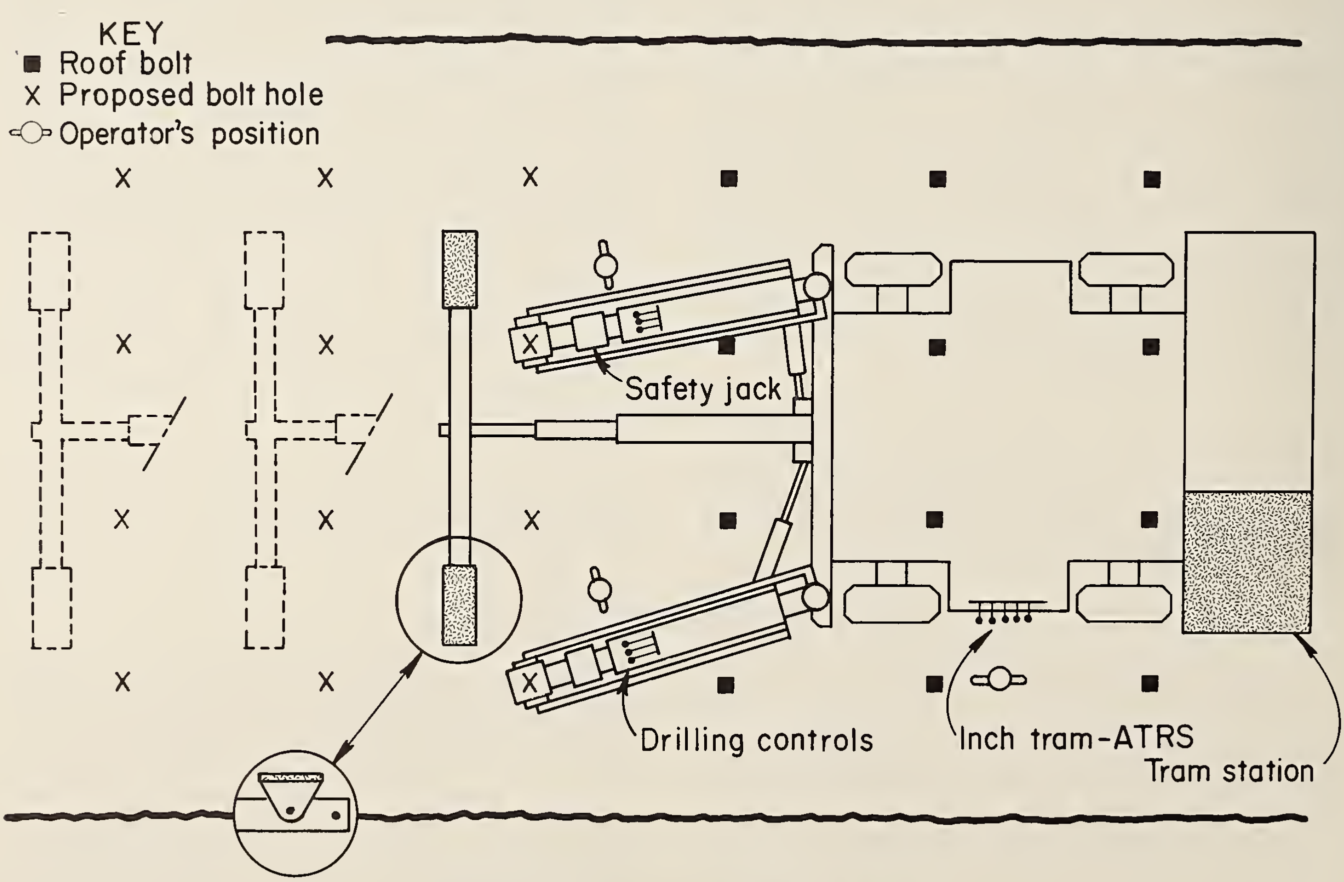

FIGURE 5. - Single-bar ATRS system.

of the single-head machines account for the difficulty. Although some operators have been successful in placing canopies over a newly attached operator's compartment, in many cases this hinders the roof bolting operations because the canopy restricts roof bolting close to the rib. Therefore, several mine operators equipped their roof bolters with ATRS systems for use in lieu of canopies over the drilling controls. Figure 6 is a plan view drawing of a fixed-head machine with an ATRS. The systems are generally modified versions of types adapted to the dual-boom roof bolting machines, and some have been approved in lieu of canopies and as sole or partial means of temporary support during the roof bolting cycle.

Although ATRS systems on single-boom bolters for use in lieu of canopies have been accepted by MSHA on a mine-to-mine basis, their use as the sole means of temporary support has been limited. The inherent design of the machine requires it to be repositioned after each bolt installation. However, improved technology, actual underground work experience, design modifications, and changing of work procedures have resulted in an increase in the use of these ATRS systems as temporary support.

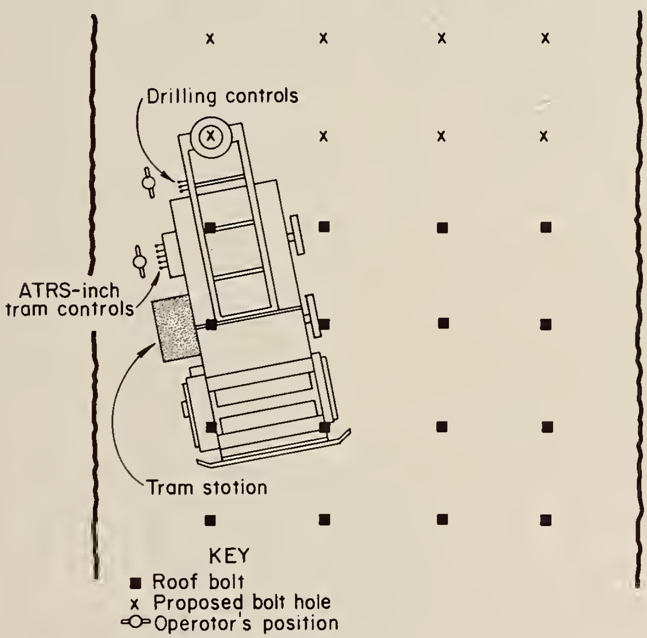

FIGURE 6. - Fixed-head machine with ATRS.

Approvals of ATRS systems on continuous miners has been increasing in the past few years. By law, canopies are required over the drilling controls on continuous miners equipped with integral drills. However, in many cases these canopies extend beyond the machine frame and require greater mining widths to accommodate them. These wider entries were detrimental to good roof control; therefore, in some mines operators have equipped their machines with ATRS systems which can be accepted in lieu of canopies over the drilling controls. Figure 7 shows a plan view of a continuous miner with ATRS jacks. The sequence of operation is as follows:

1. The roof bolt operators remain under permanent support until mining has progressed far enough to install the next row of bolts.

2. The miner operator then positions the ATRS supports firmly against the roof.

3. The bolter operators then advance to their drilling controls and install the roof bolts.

4. When the bolting is completed, the roof bolter operators retreat to a permanently supported area and the mining cycle continues.

It is easy to see that safety and production can be enhanced with the use of ATRS systems on continuous miners by roof bolting close to the face and reducing the number of moves required.

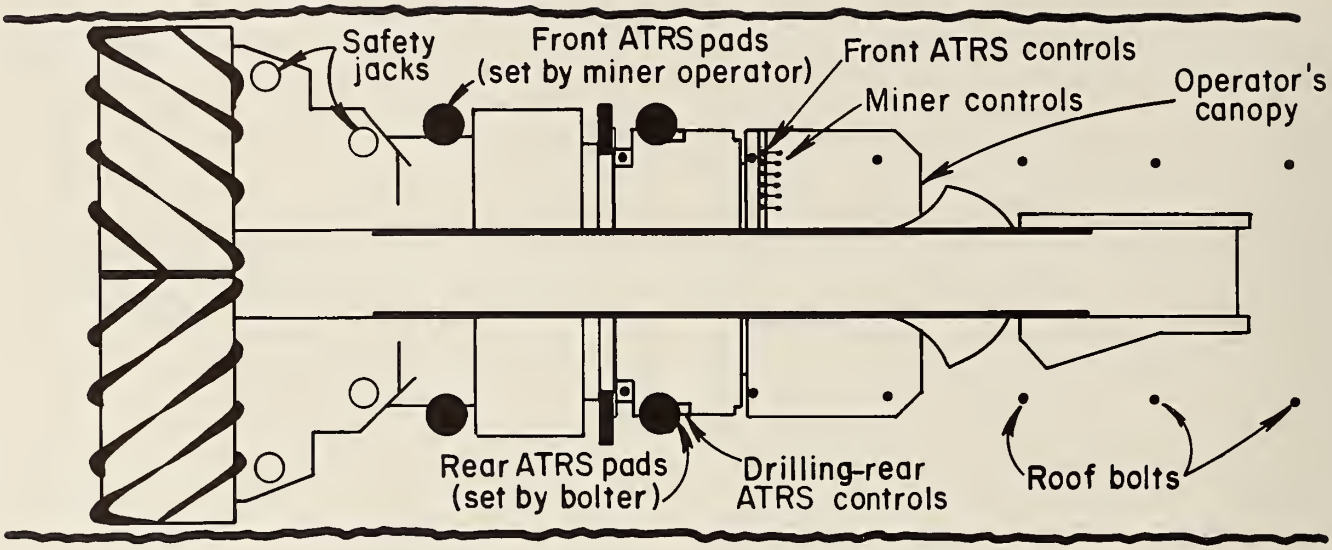

FIGURE 7. - Continuous miner with ATRS jacks.

CONCLUSION

A review of fatality statistics shows a general downward trend, particularly in the roof control area. MSHA believes that a major contributor to this reduction has been the use of ATRS systems on roof bolters and continuous miners equipped with integral bolters. The Roof Control Division of MSHA and our enforcement personnel have assisted and will continue to assist manufacturers and mining companies in the development of workable ATRS systems. The outlook is very bright for even further reduction in accidents and fatalities through the use of automated temporary roof support systems.

DEVELOPMENT OF WAIVER GUIDELINES FOR THE USE OF ATRS SYSTEMS IN WEST VIRGINIA COAL MINES

By Govindappa Puttaiah[1] and Ashok K. Agrawal[1]

INTRODUCTION

More than 35,000 miners have been killed by roof falls in underground coal mines in the past 70 yr. As shown in figure 1, the yearly toll has been dramatically reduced during the last few decades due to improved mining methods. However, the fatality figures are still unacceptably high, and further reduction could be achieved with better roof support techniques.

Table 1 shows that roof falls have historically accounted for approximately 50 pct of all underground coal mine fatalities each year (1).[2] Studies have also shown that 60 pct of the roof fall fatalities occur within 25 ft of the face. Of the 211 roof fall fatalities between 1974 and 1978, 109 occurred inby permanent supports and 46 involved miners who were manually setting or removing temporary posts or jacks.

Current mining practice requires that prior to installing permanent roof supports, miners must enter unsupported roof areas to manually set temporary supports. Such temporary supports provide protection during the bolt installation cycle. To minimize worker exposure to the unsupported roof, various Federal agencies, mining machinery manufacturers, and mining companies initiated the development of automated roof support (ATRS) systems.

[1]Division of Mining Engineering Technology, West Virginia Institute of Technology, Montgomery, WV.

[2]Underlined numbers in parentheses refer to items in the list of references at the end of this report.

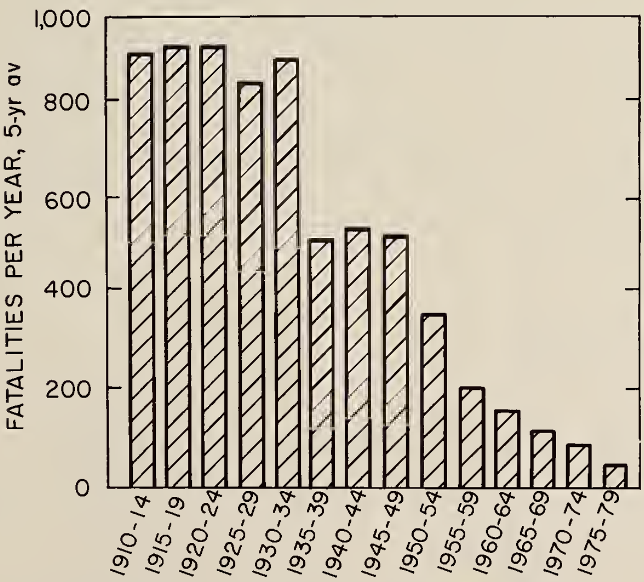

FIGURE 1. - Coal mine fatalities per year (1910-79).

TABLE 1. - Total fatality-roof fall fatality record of West Virginia coal mines (1960-79)

Year	Total fatalities	Roof fall fatalities	pct[1]
1960......	115	66	57.4
1961......	84	41	48.8
1962......	77	39	50.6
1963......	126	55	43.6
1964......	85	48	56.4
1965......	93	53	57.0
1966......	81	40	49.4
1967......	60	28	46.6
1968......	152	30	19.7
1969......	69	27	39.1
1970......	63	29	46.0
1971......	41	16	39.0
1972......	48	13	27.1
1973......	41	19	46.3
1974......	36	16	44.4
1975......	34	12	35.3
1976......	32	7	21.9
1977......	28	13	46.4
1978......	29	11	38.0
1979......	35	16	45.7

[1]Roof fall fatalities as percent of total fatalities.

These systems can provide protection during the bolting cycle by remotely setting the temporary support. Over the past decade or so, considerable progress has been made in the development of various types of ATRS systems. Use of ATRS systems in underground coal mines started to accelerate during the late 1970's. Currently, many mines are using ATRS systems on dual-boom roof bolters with great success; however, use of ATRS systems on single-boom bolters is rather limited. Studies of roof fall fatalities for 1979 and 1980 have shown that there were 18 fewer deaths inby permanent roof support in 1980 than in 1979. This may have been due in part to the increase in ATRS use during 1980.

Convinced of the potential danger due to exposure to unsupported roof and the advantages of using ATRS systems, the six-member Coal Mine Health and Safety Board of the West Virginia Department of Mines unanimously approved rules and regulations governing the use of ATRS in West Virginia coal mines. The rules and regulations (chapter 22, article 2-A, section 4, series 21 (1981) of the West Virginia Code) became effective on March 1, 1981. The regulations state in part--

5.01 (a) Twelve (12) months after the effective date of these rules and regulations all new and rebuilt, roof bolting machines and continuous mining machines with integral roof drills used in a working place in a coal mine shall be provided with an approved automated temporary roof support system: Provided, that other methods of temporarily supporting the roof may be approved by the Director in the adopted approved roof control plan.

5.02 (b) A waiver may be granted, as to the use of an automated temporary roof support system, by the Director where it has been demonstrated by the operator and determined during an investigation by an authorized representative of the Director that the use of an automated temporary roof support system would create a condition which will cause a greater hazard, to people working inby the area where permanent supports have been installed, than the method presently being employed or proposed by the operator for temporarily supporting the roof; or where the technology of an automated temporary roof support system does not exist to allow compliance with the requirements set forth in Section 5.03 of these rules and regulations. In granting a waiver as to the use of the automated temporary roof support system, the Director may approve the use of temporary jacks and posts to be used in lieu thereof.

Note that section 5.02 (b) of these rules and regulations states that a waiver may be granted from the use of the ATRS system (1) if it has been demonstrated that its use will cause a greater hazard, or (2) where the technology of an ATRS system does not exist. The above rule also charges the Director of the West Virginia Department of Mines with the responsibility of granting such waivers. In order to grant waivers on an unbiased and technically sound basis, the West Virginia Department of Mines contracted the Division of Mining Engineering Technology at West Virginia Institute of Technology to develop and recommend a set of waiver guidelines. Keeping in mind the waiver criteria set forth in the law, the investigators initiated a comprehensive study of existing ATRS systems and the problems associated with them. The following tasks were performed under the study:

1. Review of literature on ATRS technology.

2. Review of MSHA census on roof bolters and ATRS systems in West Virginia.

3. Visits to ATRS manufacturers and rebuild shops.

4. Visits to underground coal mines using the ATRS system.

5. Discussions with Federal agencies, coal industry groups, and labor associations.

6. Review of statistical information on roof falls.

7. Review of geological and engineering literature on the region's coal mine roof strata.

No attempt is made here to establish rigid guidelines; this would tend to oversimplify extremely complex relationships that exist among various ATRS-related mining variables. It became evident during the study that the procedures and criteria to be considered in the evaluation of such guidelines must be clarified. Thus, the results of this report include a thorough review of the technical status of ATRS systems and the identification of various factors that need to be evaluated in the consideration of an ATRS waiver.

ROOF BOLTER SURVEY

Section 5.01 (b) of the ATRS regulation requires that, starting March 1, 1984, all the existing roof bolting machines and continuous mining machines with integral roof drills used in a working place must be retrofitted with an approved ATRS system. Hence, it became necessary that a survey of existing roof bolters be conducted to get an idea of the magnitude of retrofitting work involved.

Table 2 shows the data obtained from a roof bolter survey conducted in District 4 of the Mine Safety and Health Administration, which covers mines in southern West Virginia. Data were compiled according to roof bolter types (dual boom or single boom), ATRS existence on the roof bolter, and manufacturer. The data show that 275 of the 290 dual-boom roof bolters now in use (95 pct) have some type of ATRS system as an integral part of the machine. However, 605 of the 698 single-boom roof bolters (almost 87 pct) do not have ATRS systems with the machine and may have to be retrofitted. Almost all the continuous miners with integral roof drills have some type of ATRS system. As shown in table 2, 400 of the 605 single-boom roof bolters without ATRS systems (almost 66 pct) are FMC (Galis) models. Fletcher, Long-Airdox, and Lee-Norse account for the majority (23 pct) of the other single-boom roof bolters without ATRS systems.

No such data were available from MSHA District 3, which covers mines in northern West Virginia. However, interviews with MSHA and the West Virginia Department of Mines personnel revealed that the use of single-boom bolters in District 3 is minimal. Therefore, the extent of retrofitting work required in northern West Virginia should not be as great as that required in southern West Virginia.

TABLE 2. - Summary of roof bolters in southern West Virginia

Manufacturer	Dual boom		Single boom	
	With ATRS	Without ATRS	With ATRS	Without ATRS
ACME	4	0	0	17
Fletcher	157	3	6	54
FMC (Galis)	46	6	73	400
Lee-Norse	64	5	7	36
Long-Airdox	4	1	4	20
Fairchild (Wilcox)	0	0	2	56
Paul's Repair Shop	0	0	0	16
Black Diamond (Wildcat)	0	0	1	4
Epling	0	0	0	2
Total	275	15	93	605

ATRS SYSTEMS

MSHA has defined a temporary roof support system (TRS) as a device that supports a minimum weight of 450 lb/ft^2 times the area to be supported. Most ATRS systems are incorporated into roof bolting machines or continuous miners equipped with integral roof bolters. The positioning controls for the ATRS are located so the operator can set the system while remaining under supported roof. Thus, an ATRS system must be extended and pressurized against the newly exposed roof remotely and is intended to replace manually installed posts and/or jacks as temporary support while the roof is being bolted.

ATRS FOR ROOF BOLTERS

Various machine manufacturers and retrofitters, coal mining companies, the Bureau of Mines, and MSHA's Roof Control Division of the Bruceton Safety Technology Center have been working for over 10 yr to design and produce safe and functional ATRS systems for different types of roof bolters. These intensive efforts have resulted in the development of several workable ATRS systems.

All currently available ATRS systems can be broadly categorized as either integral types or satellite types.

An integral type of ATRS system is one in which the system is rigidly attached to the roof bolting machine. Integral-type ATRS systems are available for most existing dual-boom and some single-boom roof bolting machines. The three most common support mechanisms currently available are the ring type, T-bar type, and H-bar type.

Figure 2 shows the ring type (also called the safety-arm type) ATRS developed to provide temporary roof support in the immediate area of the roof while the bolt is being installed. This type consists of a roof support structure (ring) mounted above each drill boom. A steel arm, a pair of arms, or hydraulic cylinders usually connect the support structure to the machine frame and/or the mine floor. The support structures and steel arms have various sizes and configurations and are pressurized against the mine roof from a remote position by the hydraulic cylinders. The safety-arm ATRS system must be repositioned remotely before each bolt is installed.

Figure 3 shows a T-bar system, which usually consists of either one or two

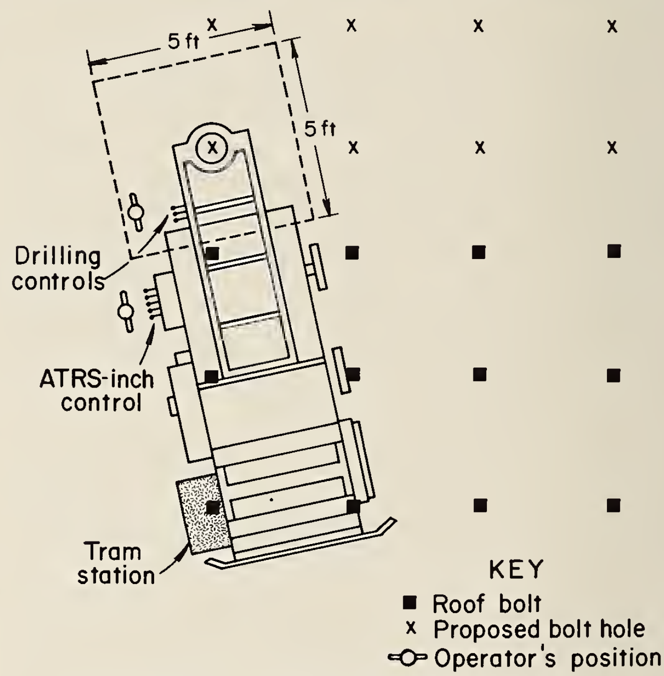

FIGURE 2. - Ring-type ATRS system.

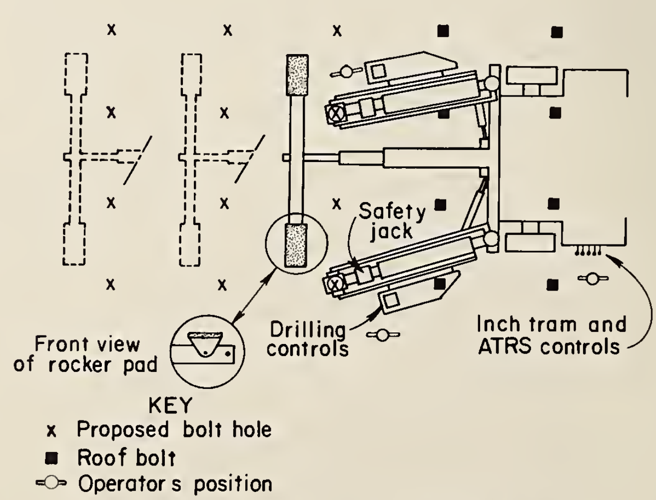

FIGURE 3. - T-bar-type ATRS system.

bars equipped with roof contact pads mounted atop a hydraulic jack that can be pressurized against the mine roof from under the permanently supported roof. This system is generally attached to a dual-boom roof bolter.

Figure 4 shows an H-bar type of system used predominantly as a retrofit kit for single-boom bolters. The basic support and operating mechanisms are similar to those of the ring or safety-arm types.

The satellite type of ATRS system is being designed mainly for single-boom roof bolters. The Bureau of Mines and several industry organizations are independently involved in the development and field testing of satellite-type systems (fig. 5). The system basically consists of a steel beam or steel pads supported by double-acting, telescoping hydraulic cylinders. The ATRS is carried from place to place and row to row on the drill head but is not an integral part of the machine. During bolting, the support structure is connected to the machine only by hydraulic lines. A detailed description of this system is available through the Bureau of Mines (2).

ATRS SYSTEMS FOR CONTINUOUS MINERS

The ATRS law was written to include both roof bolters and continuous miners with integral roof bolters. Although many roof bolter designs are available, only two companies are currently manufacturing continuous miners with on-board roof bolters. These machines have hydraulic roof support jacks mounted adjacent to the drilling and bolting modules just inby the miner operator's compartment. The jacks can be operated from a safe distance under permanently supported roof. Since both of these miner-bolters already have ATRS systems, no further discussion of these machines is warranted.

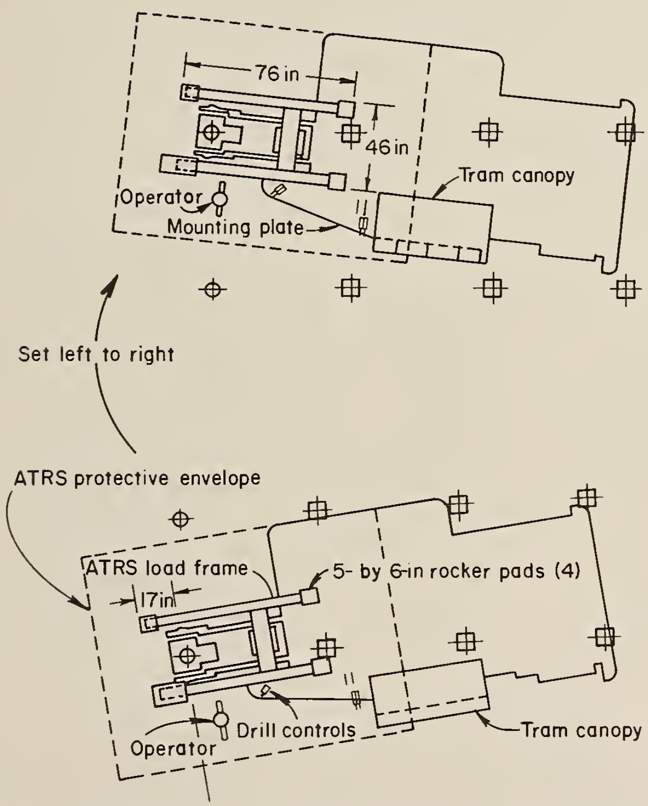

FIGURE 4. - H-bar-type ATRS system.

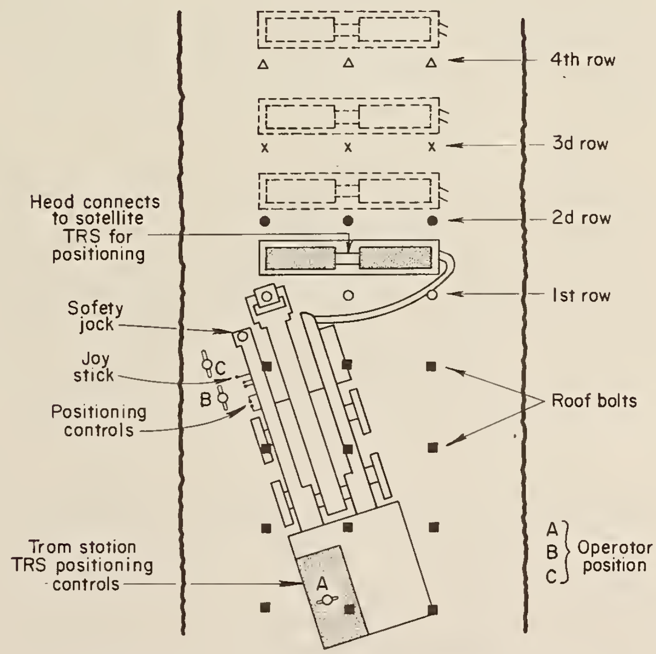

FIGURE 5. - Satellite-type ATRS system.

NEED FOR ATRS WAIVERS

As noted earlier, section 5.02 (b) of the Rules and Regulations Governing the Use of ATRS systems provides that the key issues to be considered in seeking and granting a waiver are (1) the determination that an ATRS system would create a *greater* hazard than the method presently being employed or proposed by the operator, and (2) lack of technology to allow compliance with the ATRS law. Mine geology obviously influences these considerations.

HAZARD POSSIBILITIES DUE TO ATRS

A greater hazard to miners (i.e., roof bolter operator and helpers) may be caused by employing an ATRS for the following reasons:

Reduced Visibility.--The use of ATRS may cause reduced visibility of the roof surfaces and the surrounding space in general, particularly in thin-seam coal mines. The roof bolter operator may have difficulty in locating the bolt holes within the tolerances permitted by the roof control plan. This may result in improperly supported roof with the possibility of roof falls and/or citations.

Roof or Floor Conditions.--Severe uneven roof or floor conditions, especially if they are recurring features in the mine, may result in insufficient or nonuniform contact between ATRS support pads and the roof. Under these conditions the use of conventional post-type temporary supports may provide better contact with the roof and greater safety than an ATRS.

Induced Pressure.--The upward pressure created on an unsupported roof while the ATRS is being set up may destabilize the roof, especially if the immediate roof rock has low shear strength or is intensely fractured. However, since the upward force exerted by an ATRS can be controlled by the bolter manufacturer and the drill operator, this should not be considered a criterion for granting a waiver.

Mobility Considerations.--Movement of an ATRS, particularly the bar type, in a confined space near the face may cause hazardous conditions such as knocking down temporary posts, initiating rib and roof failures by unintentional contact, physical damage to face ventilation systems, etc.

LACK OF ATRS TECHNOLOGY

Roof bolter size and coal seam thickness are the two main factors that need to be considered during the evaluation of any ATRS technology. Interviews with the manufacturers and retrofitters have revealed that the size of the roof bolter, and not the type, was the major problem in the development of a workable ATRS system. Because a direct relationship exists between the bolter size and coal seam thickness, the presence or lack of ATRS technology depends on coal seam thickness. In this report, a thin seam is defined as one that is less than 36 in; medium, between 36 and 60 in; thick, between 60 and 100 in; and very thick, over 100 in.

In general, there are few ATRS systems available for thin coal seams. However, discussions with manufacturers of roof bolters indicate that efforts are being made to develop ATRS systems for low coal, primarily for new roof bolters. However, as shown in table 2, a large number of existing single-boom roof bolters must be retrofitted with ATRS by March 1, 1984. Since most of the requests for ATRS waivers will be for thin-seam roof bolters, careful examination must be made of the available retrofit technology.

Some large manufacturers are developing retrofit ATRS systems for their existing thin-seam roof bolters. Several designs are beyond the prototype stage, and others are on the drawing board. These designs are expected to be available before 1984 and should be able to meet the needs of most existing thin-seam roof bolters.

A wide variety of ATRS systems are now available for roof bolters used in medium seams. Therefore, no waivers should be granted to medium-seam roof bolters based on seam thickness alone.

Sufficient ATRS technology also exists for thick-seam roof bolters; therefore, no waivers should be granted. Although ATRS technology for very thick coal seams (above 100 in) is not as well developed as it is for medium and thick seams, very thick seam mines are not common in West Virginia. Therefore, requests for waivers in very thick seams can easily be treated on an individual basis.

MINE GEOLOGY

The frequency of roof falls is closely related to immediate roof conditions (tables 3 and 4, figure 6) (3). As shown in table 3, shale was the immediate roof rock in over 80 pct of roof falls where fatalities occurred. Table 4 shows that thickness of the shale roof has a significant impact on roof stability; as shale

TABLE 3. - Roof conditions where fatalities occurred

Rock type	Good to firm	Fair	Poor	Bad	Total cases	pct
Shale...........	8	46	140	22	216	80.29
Sandstone.......	5	2	10	2	19	7.06
Soapstone.......	0	0	0	1	1	.38
Head or top coal	0	6	23	4	33	12.27
Total........	13	54	173	29	269	100.00

TABLE 4. - Comparison of roof fall data by period

	July 1973-June 1978			July 1978-June 1980			
	Mine acres	Roof falls	Falls per acre	Mine acres	Roof falls	Falls per acre	Reduction in F/A,[1] pct
Shale roof thickness, ft:							
0 to 5..........	118.2	30	0.16	246.0	10	0.04	75
>5 to 10..........	111.8	56	.50	71.5	17	.24	52
>10 to 20..........	76.2	49	.64	31.8	9	.28	56
>20 to 30..........	53.9	71	1.32	56.0	11	.20	85
>30 to 40..........	30.1	50	1.66	18.6	0	.0	100
>40 to 50..........	13.5	37	2.74	29.8	11	.37	86
Total or average	473.7	293	.62	453.7	58	.13	80
Fractured roof.......	91.2	84	.92	19.5	8	.41	55
Unfractured roof.....	382.5	209	.55	434.2	50	.12	79
Extraction ratio (e):							
0.33 to 0.18......	77.3	9	.12	242.7	12	.05	58
>0.38 to 0.43......	32.7	5	.15	174.2	34	.19	[2]27
>0.43 to 0.48......	363.7	279	.77	36.8	12	.33	57

[1]Falls per acre of mine development.

[2]This apparent increase in falls per acre is probably a result of the 0.15 figure being too low (5 falls was an incomplete sample). A more realistic figure would have been 0.45, or midway between 0.12 and 0.77. Then the 0.19 figure for 1978-80 would represent an equivalent 57 pct reduction over the first period.

roof thickness increased from 5 to 20 ft, roof falls per acre increased from 0.16 to 0.64.

Local defects such as slickensides, pots, slips, loose shale, fractures, and faults are associated with a majority of roof falls and fatalities (fig. 6). Furthermore, roof rock properties, especially those of shale, are affected by changing moisture conditions in the mine. Therefore, a thorough evaluation of immediate roof geology and the mine moisture conditions should be made as part of any waiver consideration.

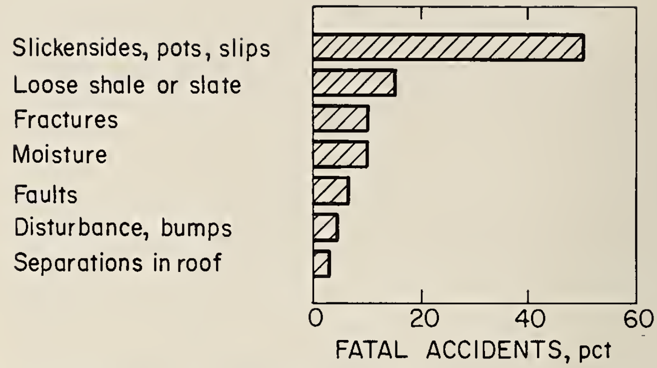

FIGURE 6. - Geological conditions contributing to fatal roof falls.

RECOMMENDATIONS

1. The West Virginia Department of Mines should define more precisely what a waiver is likely to encompass. Opinions of manufacturers, operators, safety and training directors, and miners show no consensus whatsoever on the extent of an ATRS waiver. Some believe that a mine-wide waiver may be necessary, while others think that it may be needed for only a part of the mine. Still others feel that a waiver may be necessary only for a particular machine. This confusion as to the intent and applicability of the ATRS waiver should be resolved before considering any waiver request.

2. The Department of Mines should define the term "Waiver" more precisely in order to make the distinction between a "waiver" and a modification to the existing mine roof control plan. Many mines will have to change their present roof control plans to allow incorporation of ATRS systems.

3. A comprehensive study of all factors discussd in this report should be conducted upon receipt of a waiver application.

4. All factors should be weighed on their merits and considered together and no single factor should be the deciding criterion, with the possible exception of available ATRS technology.

5. All roof bolter operators and helpers not already using ATRS systems should be provided with formal hands-on training in the use of the ATRS system.

6. The Department of Mines should conduct a series of seminars on current ATRS technology and waiver granting procedures. These seminars should be structured to review the current status of ATRS technology and, most importantly, inform the mining industry of the requirements and interpretation of the ATRS law.

7. The Department of Mines should send a letter of reminder to all underground coal mine operators regarding the March 1984 effective date of the ATRS regulations.

Although nearly all manufacturers have either developed or are actively working on developing ATRS for their roof bolters, and a few are gearing up to meet the expected retrofit demand, this was not the case with the majority of the manufacturers. They seem to be waiting for orders from operators before manufacturing and stocking retrofit kits. We believe that this lack of preparedness for the anticipated surge in demand for ATRS kits could create backlog problems as the deadline approaches. However, some larger companies that

own and operate their own rebuild shops are already retrofitting all their roof bolters with ATRS, and some smaller welding shops are also involved in or preparing to go into this business. This should ease the situation to some extent.

OTHER OBSERVATIONS AND SUGGESTIONS

COSTS ASSOCIATED WITH ATRS

All retrofitted ATRS systems require that the roof bolter be removed from the face for this purpose. Therefore, two types of costs are involved with retrofitting of an ATRS: (1) costs occurring from the loss of production and (2) expenses attributable to the purchase and installation of the ATRS system. The costs resulting from loss of production depend on a number of variables; most of these are subjective in nature and cannot be quantified easily. Although the second cost category should be available from manufacturers or retrofit shops, many medium- to large-sized operators typically schedule roof bolter overhauling with retrofitting of ATRS. This makes it difficult to accurately estimate the cost of retrofitting alone. The cost of many ATRS systems for dual-boom bolters can be considered irrelevant since most of them already have ATRS. The costs associated with retrofitting thin- to medium-seam roof bolters range from about $6,000 to $15,000.

SOME CONCERNS ON THE ATRS LAW AND RELATED MATTERS

Coal mine operators and safety directors expressed the following concerns about the effects of the ATRS law:

1. Does the ATRS law prohibit the use of any kind of posts at all in underground mines at the working place?

2. Does the ATRS law prohibit the use of posts (timber or mechanical) as additional temporary support *with* an ATRS if roof conditions so demand?

3. Does the ATRS law prohibit the presence of men beneath unsupported roof under *all* circumstances?

The answers to these three questions are all "no," so the fears of many mine operators regarding the ATRS regulations are unfounded.

In general, the overall reception to the law has been positive. This underscores the safety features of the law, which are recognized as desirable by all concerned. Interviews with manufacturers, mine operators, users, fabricators, R&D engineers, etc., showed that most of them are fully aware of the West Virginia ATRS law. Although some reservations to the law were observed as noted above, these were primarily due to lack of overall understanding of its intent and applicability. Therefore, we reiterate the need for a clarification of these concerns by the West Virginia Department of Mines.

REFERENCES

1. State of West Virginia. Department of Mines Annual Report and Directory of Mines, Years 1969 through 1979.

2. Chislaghi, C. T., and T. E. Marshall. Field Test of An Automated Temporary Roof Support (ATRS) on a Low-Coal, Single Fixed-Head Roof-Bolting Machine (Squirmer). BuMines TPR 119, 1982, 11 pp.

3. Peng, S. S. Coal Mine Ground Control. Wiley, 1978, pp. 31-32.

FIELD TEST OF AN ATRS SYSTEM ON A LOW-COAL, SINGLE FIXED-HEAD ROOF BOLTING MACHINE (SQUIRMER)

By Edward A. Barrett[1] and Thomas E. Marshall[2]

ABSTRACT

An economical, remotely operated (automated), temporary roof support (ATRS) has been developed by the Bureau of Mines for use on a single fixed-head roof bolting machine (squirmer) that operates in low coal seams (less than 42 in thick). The ATRS eliminates the need for squirmer operators and helpers to go under unsupported roof to set or remove temporary support prior to or during the roof bolting cycle--a task that annually accounts for approximately 20 pct of all roof fall fatalities. The ATRS can be adapted to any squirmer used in the U.S. low coal fields. A prototype ATRS was field-tested at Imperial Colliery Co.'s Mine No. 20 in Eskdale, WV. The Mine No. 20 amended roof-control plan, which requires the use of the Bureau's ATRS as temporary support during face bolting, has been approved by the Mine Safety and Health Administration (MSHA), U.S. Department of Labor.

INTRODUCTION

The Bureau developed an ATRS for three reasons: (1) Squirmer operators and helpers are exposed to unsupported roof on a daily basis, (2) West Virginia mine law[3] requires ATRS on squirmers, and (3) original equipment manufacturers and coal mine operators have not developed adequate ATRS for squirmers.

A statutory provision of the Federal Coal Mine Health and Safety Act of 1969 states that "No person shall proceed beyond the last permanent support unless adequate temporary support is provided" (30 CFR 75.200). However, since the law was written, there have been no practical means available that would allow squirmer operators and helpers to set temporary supports from under permanently supported roof. Therefore, this provision was interpreted to mean "In areas where permanent artificial support is required, temporary support should be used until such permanent support is installed," and "Only those persons engaged in installing temporary support should be allowed to proceed beyond the last permanent support until such temporary supports are installed" [30 CFR 75.200-13 (a) (1-2)]. Annually, approximately 20 pct of all roof fall fatalities involve miners who have gone beyond the last permanent support to set or remove temporary roof support prior to or during the roof bolting cycle.

Low coal mine operators in West Virginia need ATRS because the State mine law requires that roof bolting machines used in working places be equipped with ATRS, regardless of coal seam height. New machines must be equipped by 1982, and all machines by 1984.

Over 3,500 squirmers are in use today in southern West Virginia, eastern Kentucky, and southwestern Virginia, and approximately 60 pct of these have no ATRS, cab, or canopy. Because of space limitations in low coal, not many ATRS have been commercially developed for squirmers, although many different ATRS systems have been commercially developed for roof bolting machines used in high coal. Most

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[2]Engineering technician.
Pittsburgh Research Center, Bureau of Mines, Pittsburgh, PA.
[3]West Virginia Administrative Regulations, chapter 22-4, series 21, March 1981.

ATRS designed for squirmers reduce workspace and operator visibility, creating a situation that reduces or compromises the existing safety level, with a greater safety hazard to squirmer operators and helpers working inby the last row of permanent support.

All design work and prototype fabrication of the Bureau ATRS was done by the Roof Support Group at the Pittsburgh Research Center. All fieldwork was done in the No. 2 gas seam (36 to 42 in thick) at Mine No. 20 of the Imperial Colliery Co. in Eskdale, WV.

ACKNOWLEDGMENTS

The Bureau acknowledges the cooperation it received from the Imperial Colliery Co., especially the personnel of Mine No. 20, who participated enthusiastically in the modifications and tests. In addition, the Bureau acknowledges the cooperation of the Mine Safety and Health Administration (MSHA), U.S. Department of Labor; in particular, personnel of the Bruceton Safety Technology Center and the Mount Hope Subdistrict. Without their technical suggestions and assistance, this project could not have been completed.

DESCRIPTION OF ATRS

The Bureau of Mines' ATRS is a 10-ft-long, steel, wide-flange beam supported by two double-acting, telescoping hydraulic cylinders (fig. 1). A steel sleeve, mounted on the bottom center of the beam, is designed to fit over the top of the squirmer drill head (fig. 2). The ATRS is carried from place to place and from row to row on the squirmer drill head (fig. 3). During bolting it is connected to the squirmer only by two hydraulic lines (fig. 4). Because the ATRS weighs only about 400 lb, the squirmer drill head and boom do not have to be rebuilt to carry it. Total cost of the beam and cylinders is approximately $1,800. In-house fabrication of the ATRS took 8 worker-hours. The Bureau piped the ATRS hydraulic circuit at a cost of $150 and 32 worker-hours.

The Bureau's ATRS design meets MSHA's general design requirements and West Virginia's design and operating requirements for such support. Both hydraulic cylinders supporting the ATRS have check valves to prevent sudden collapse of the ATRS in the event of a ruptured hydraulic line or broken hydraulic fitting. In addition, the ATRS hydraulic circuit contains an accumulator, charged by squirmer line hydraulic pressure, which keeps the ATRS firmly set against the mine roof even if the roof rock is pulled up during the bolting cycle. The ATRS can elastically support the minimum required deadweight load of 33,750 lb.[4] Figures 5 through 8 include all design drawings and the hydraulic schematic.

SQUIRMER STREAMLINING

West Virginia State mine law requires the streamlining of any roof bolting machine before it can be retrofitted with ATRS. Imperial Colliery personnel streamlined a 15-yr-old squirmer for the field test. The ATRS controls were located 5 ft back from the drill head so that they can be operated only from beneath permanently supported roof (fig. 9). Full tram controls are located with the ATRS controls, and the full tram speed was left at 150 ft/min. Inch-tram controls were located at the drill station, and inch tram speed was reduced to 65 ft/min. No ATRS controls were located at the drill station. Other streamlining work included removal of the bolt tray and tram deck, installation of low volume-high torque tram motors, and

[4]Capacity certified by a professional engineer.

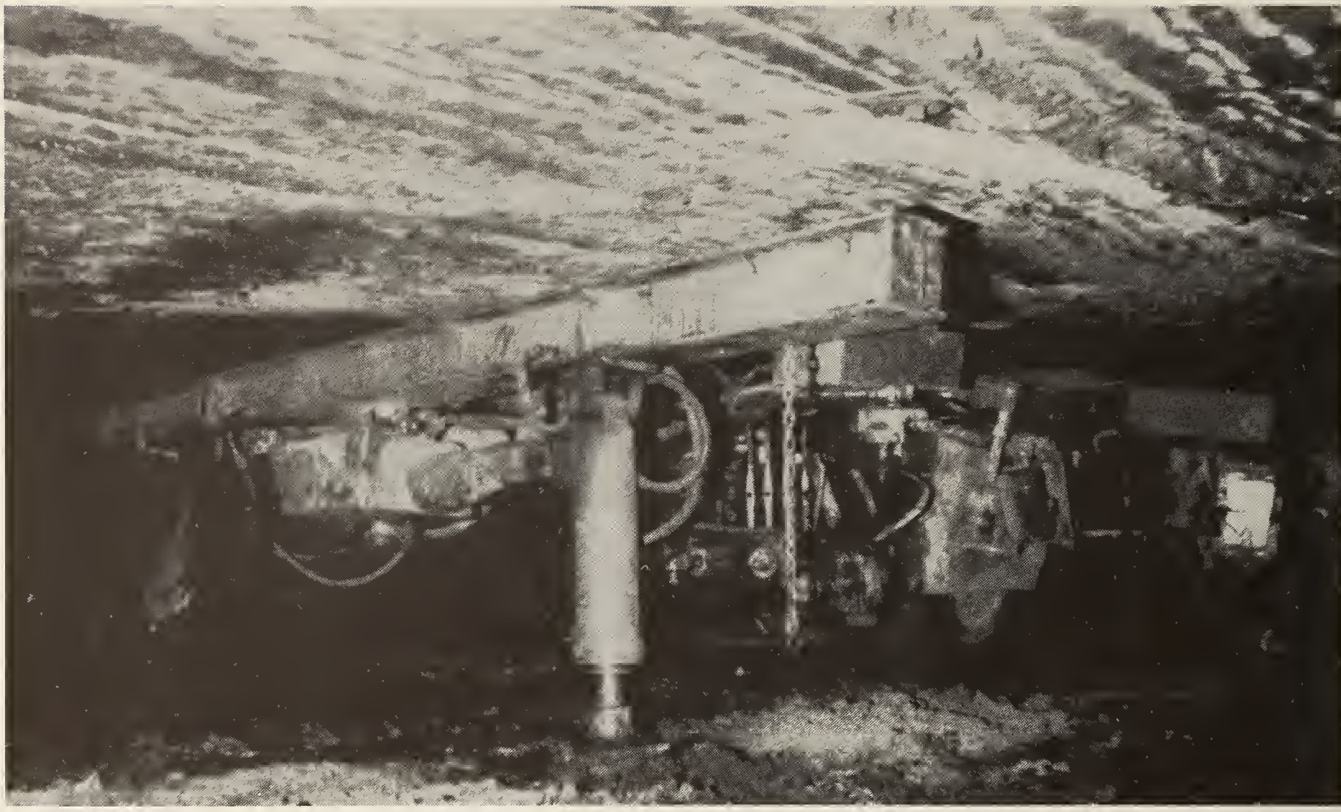

FIGURE 1. - Bureau of Mines ATRS.

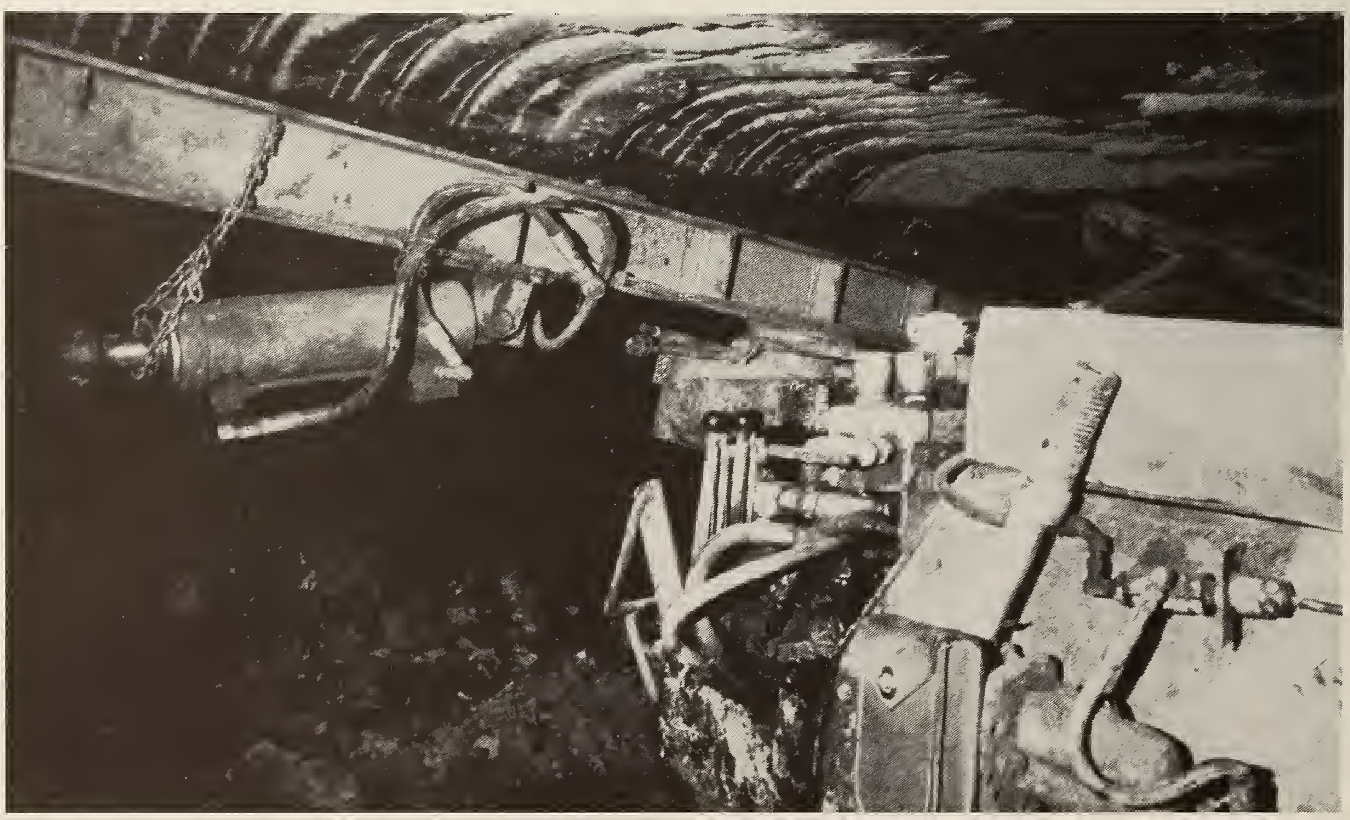

FIGURE 2. - ATRS mounted on drill head for transport from place to place.

FIGURE 3. - ATRS carried from place to place.

FIGURE 4. - ATRS location during bolting.

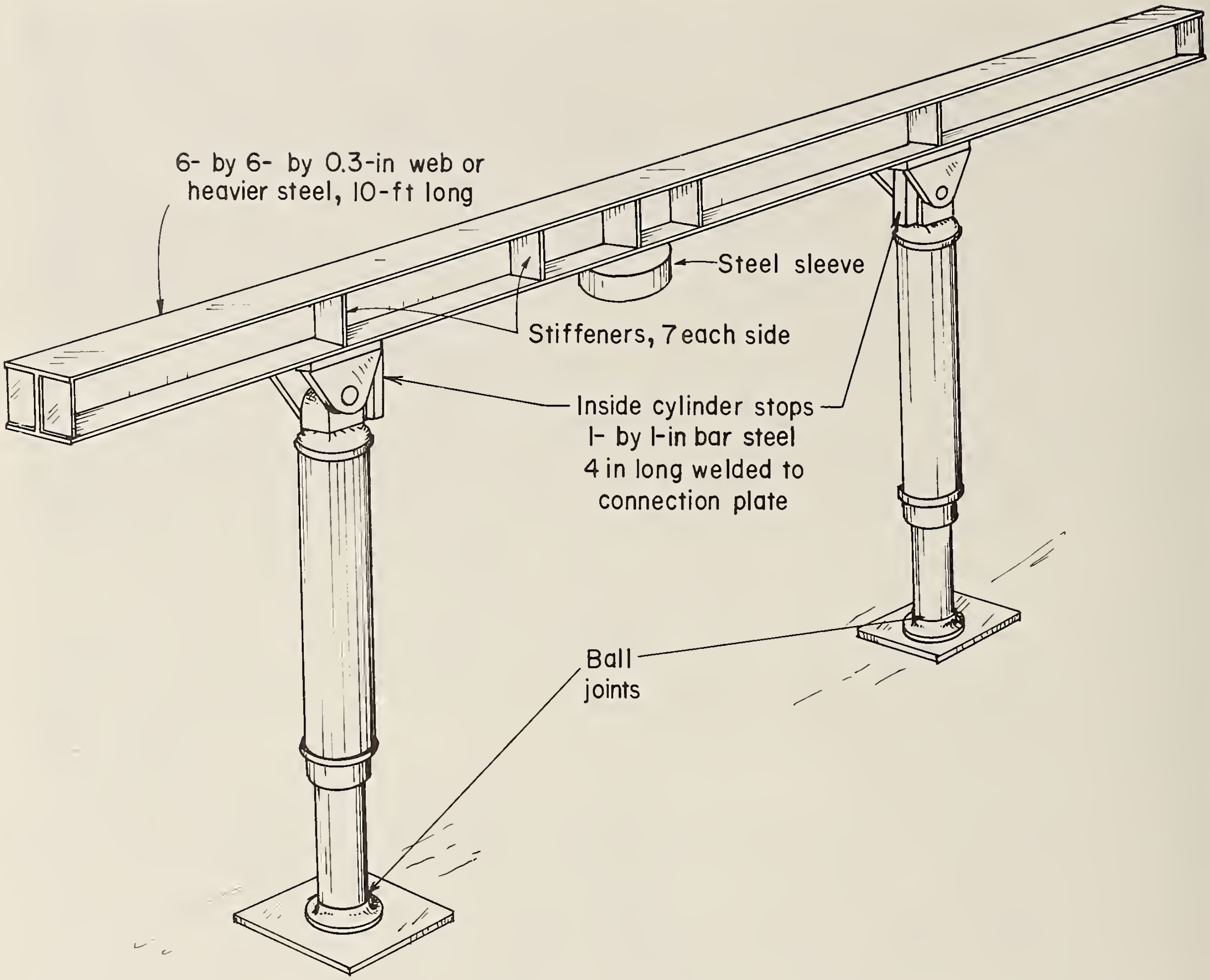

FIGURE 5. - General assembly of ATRS.

moving the squirmer front wheels 8 in forward to provide space for the ATRS and full tram controls. Total cost of this work was $5,500 and it required 96 worker-hours to complete.

FIELD TEST AND RESULTS

With MSHA and West Virginia approval, Imperial Colliery placed the ATRS in the production cycle at Mine No. 20 for 5 months. Bolting was on 4-ft centers in 20-ft-wide entries and crosscuts. For the Bureau's ATRS, the bolting cycle was the following:

Step 1. - The squirmer operator, at the full tram controls (fig. 9), trams into the center of an entry and stops when the ATRS is under the last row of permanent support.

Step 2. - The operator lowers the drill head and ATRS to the mine floor, using the boom control located beside the full tram and ATRS controls; moves from the full tram position to the beam (ATRS); and unhooks the hydraulic cylinder leg on

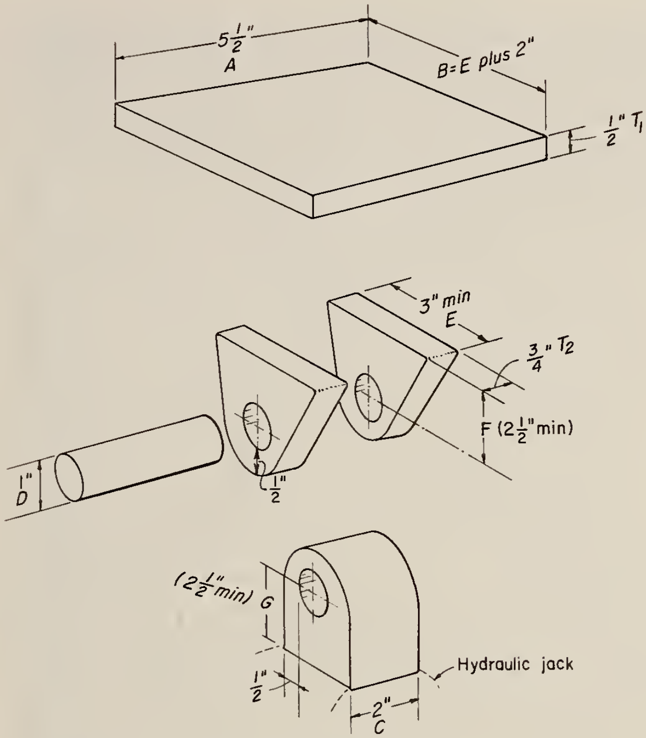

FIGURE 6. - Detail of ATRS connection without cylinder stop.

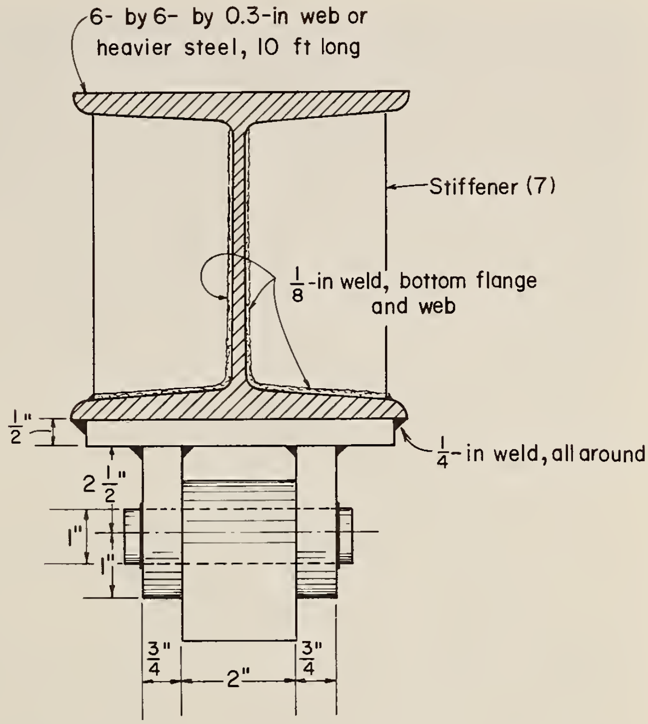

FIGURE 7. - End view of ATRS and connection without cylinder stop.

the operator side that is chained to the beam, while the helper does the same to the leg on the right side (fig. 10).

Step 3. - The operator raises the drill head and ATRS, using the boom control at the drill station, just high enough to let the legs hang down perpendicular to the mine floor; locks the legs perpendicular to the mine floor; moves back to the full tram and ATRS controls; and trams the squirmer inby.

Step 4. - The operator stops when under the last row of permanent support. The ATRS is now 5 ft inby the last row of permanent support and 5 ft from each rib.

Step 5. - The operator places the ATRS against the roof, using the boom control located beside the full tram and ATRS controls, and then extends the legs to the mine floor, using the ATRS control, until the beam is firmly set against the roof and the legs are firmly set against the mine floor.

Step 6. - The operator lowers the drill head away from the beam, using the boom control located beside the full tram and ATRS controls.

Step 7. - At this point, the operator moves to the drill station, pushes in the diversion valve, which diverts all hydraulic fluid from the full tram and ATRS circuits to the inch tram and drill circuits, and "inches" the squirmer to the left rib to begin bolting. During bolting the squirmer is connected to the ATRS only by two hydraulic lines (fig. 4).

Step 8. - After a row of permanent support is installed, the operator raises the drill head into the beam, using the boom control at the drill station; pulls out the diversion valve, which diverts all the hydraulic fluid back to the full tram and ATRS circuits from the inch tram and drill circuits; moves to the full tram and ATRS controls; and retracts the legs, using the ATRS control.

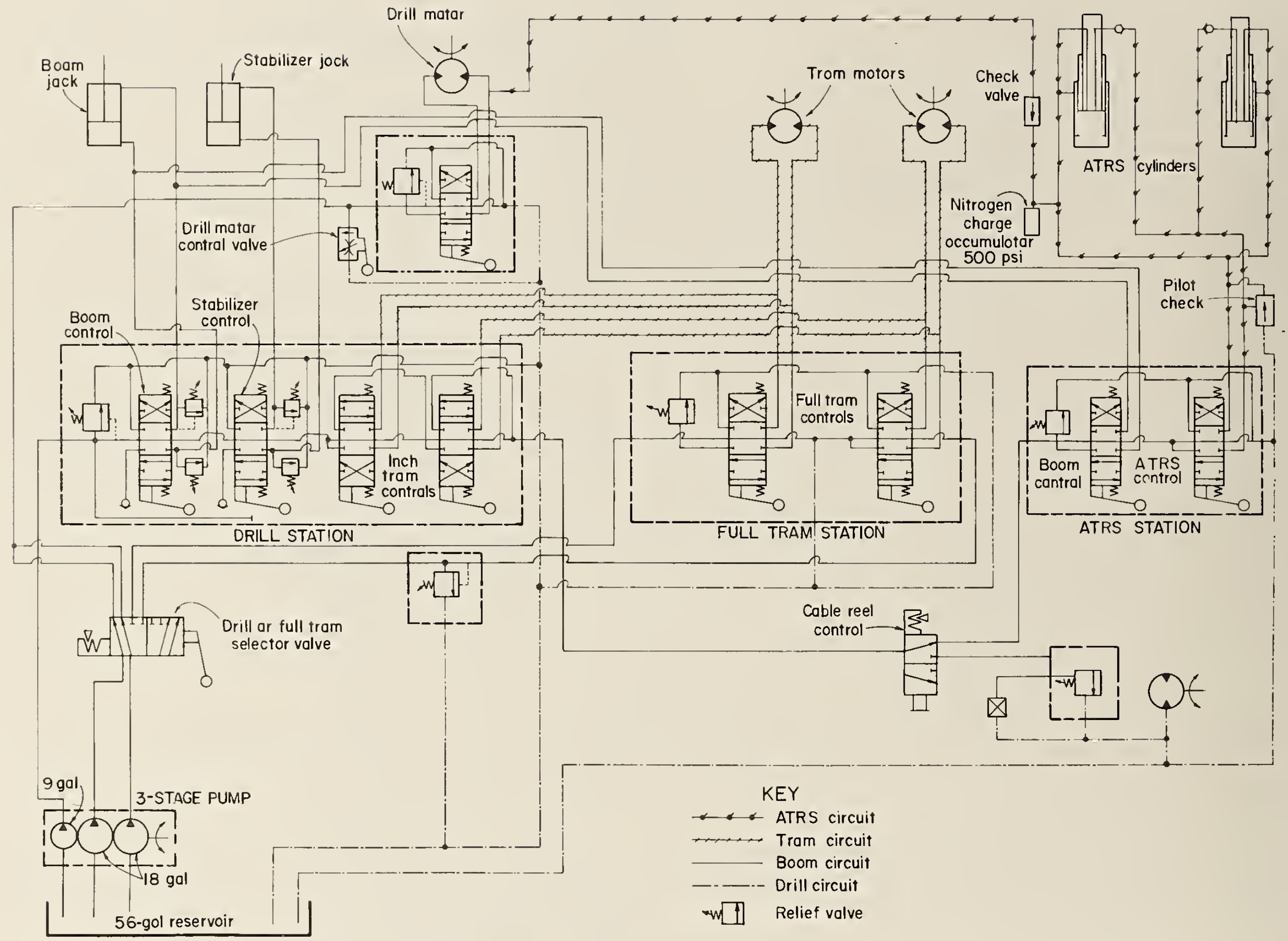

FIGURE 8. - Hydraulic schematic of ATRS for streamlining.

Step 9. - The operator lowers the drill head and ATRS, using the boom control located beside the full tram and ATRS controls, just enough to tram the squirmer 4 ft inby.

Step 10. - When under the row of permanent roof supoort that has just been installed, the operator stops and repeats steps 5 through 9. This cycle is repeated until the last bolt is in place.

Step 11. - Then the operator raises the drill head into the beam, using the boom control at the drill station; unlocks the legs; pulls out the diversion valve; moves to the ATRS controls; retracts the legs; moves back to the drill station; lowers the drill head and ATRS to the mine floor, using the boom control at the drill station; chains the leg on the operator side to the beam, while the helper does the same to the leg on the right side; moves back to the full tram and ATRS controls; and trams to the next place, where steps 1 through 11 are repeated.

No operating or maintenance problems were encountered during the 5 months of testing. With the addition of the ATRS, the squirmer could still turn 180° within the 20-ft-wide entries and crosscuts, and could tram through check curtains and line brattice without pulling them down. Comparative time studies of the same

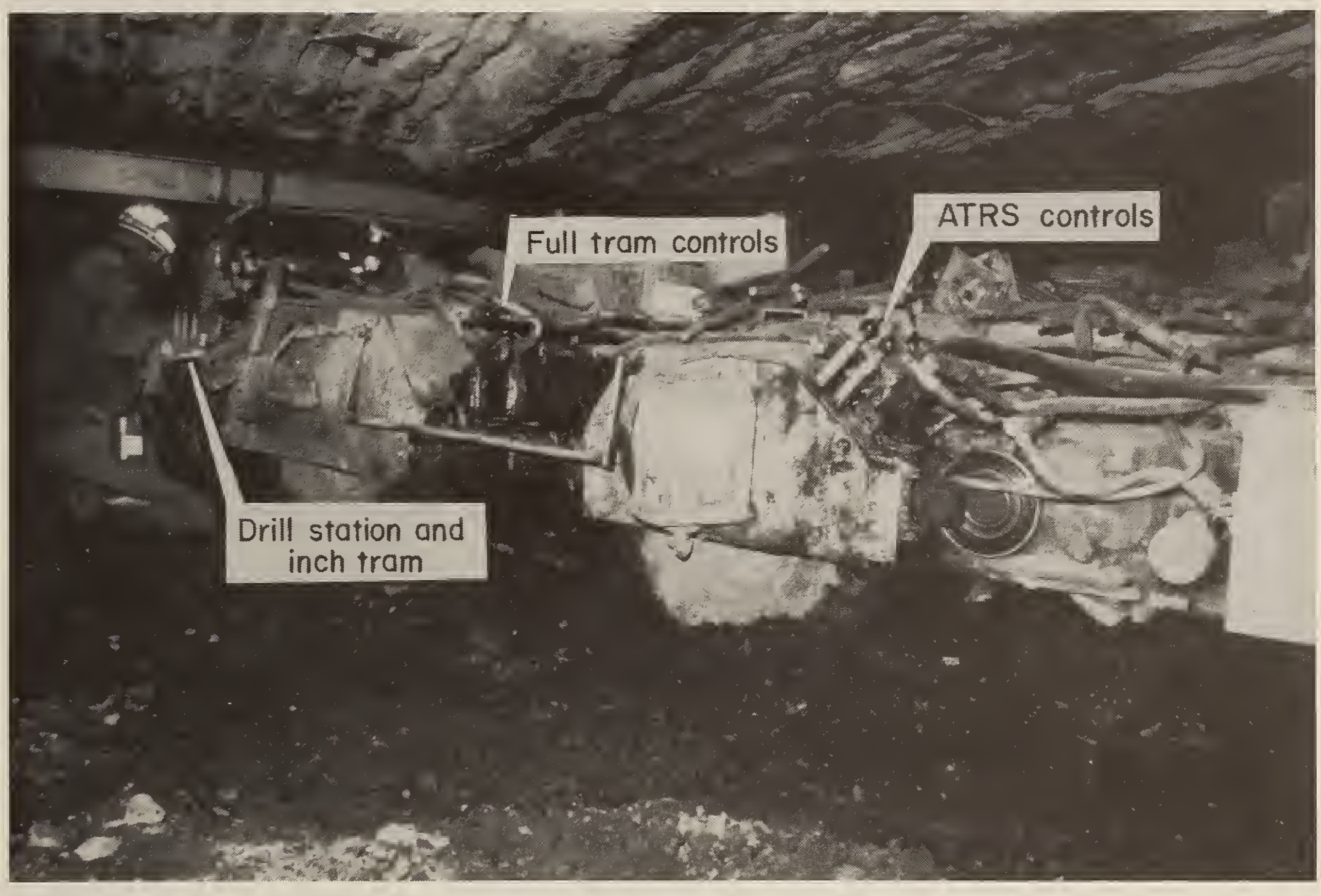

FIGURE 9. - Control bank locations.

bolting crew showed that it took an average of 5 min less to bolt a place with the ATRS than with mechanical jacks. The bolting crew preferred the ATRS. After testing, an amended roof control plan requiring the use of the Bureau's ATRS during face bolting at Mine No. 20 was submitted by the Imperial Colliery Co. and approved by MSHA (District 4, Mount Hope Subdistrict, Montgomery Field Office).

CONCLUSIONS

The Bureau's ATRS eliminates the need for squirmer operators and helpers to go under unsupported roof to set or remove temporary support prior to or during the roof bolting cycle. The squirmer operator will always be under permanently supported roof while setting or removing the ATRS and will not be able to bolt inby the ATRS because of its size and position in the entry. In addition, this inexpensive and lightweight ATRS does not reduce the squirmer operator's workspace.

The ATRS has the potential to be immediately used in U.S. coal mines. Although the Bureau's ATRS was field-tested with only one squirmer, it can be adapted to the drill head of any squirmer operating in low coal and it can be fabricated in any mine shop. The ATRS can be retrofitted to the squirmer during maintenance shifts if a streamlined squirmer is available.

FIGURE 10. - ATRS hydraulic cylinder legs unhooked.

Bolting does not stop if problems occur with the Bureau's ATRS, since it can be removed from the area and bolting can continue with mechanical jacks serving as temporary supports. (If problems arise or maintenance must be performed on any other ATRS, the squirmer must be taken out of production.) In addition, this ATRS does not have to be reset for each bolt hole as do the ring-type and ironing-board-type ATRS. It is reset only after a complete row of bolts is installed. The Bureau's ATRS provides a support envelope for the squirmer operator and does not obstruct the installation of bolts 2 ft from either rib. It has the potential to drastically reduce roof fall fatalities and injuries and lead to increased productivity, if used as outlined in this document.

DEVELOPMENT OF AN ATRS SYSTEM FOR FAIRCHILD INC. ROOF DRILLS

By George Cobb[1]

FAIRCHILD BOLTING MACHINES

Fairchild Inc.'s J-4 and J-6 roof bolters (fig. 1) have been in existence for over 20 yr. When introduced to the industry they were immediately accepted as the standard for bolting machines with continuous mining in low seams. The bolters were among the first to have a fully enclosed gear-driven tram system, which greatly decreased the interference of mud or other foreign materials while tramming. The Research and Development Division of Fairchild, located in Beckley, WV, has upgraded the bolter through the years, such as increasing the hydraulic capacity and installing a dual lift on the bolter head. Now the Research and Development Division is introducing an ATRS system for the bolters.

ATRS WITH AN EXTENDED HEAD BOLTER

At first the Research and Development engineers designed an ATRS system compatible with Fairchild's original bolter designs. A prototype was developed, tested underground, and brought back into the laboratory for refinement. Mine operators, the West Virginia Department of Mines, West Virginia Tech University, and MSHA provided valuable assistance during

[1]Director of marketing, Fairchild Inc., Beckley, WV.

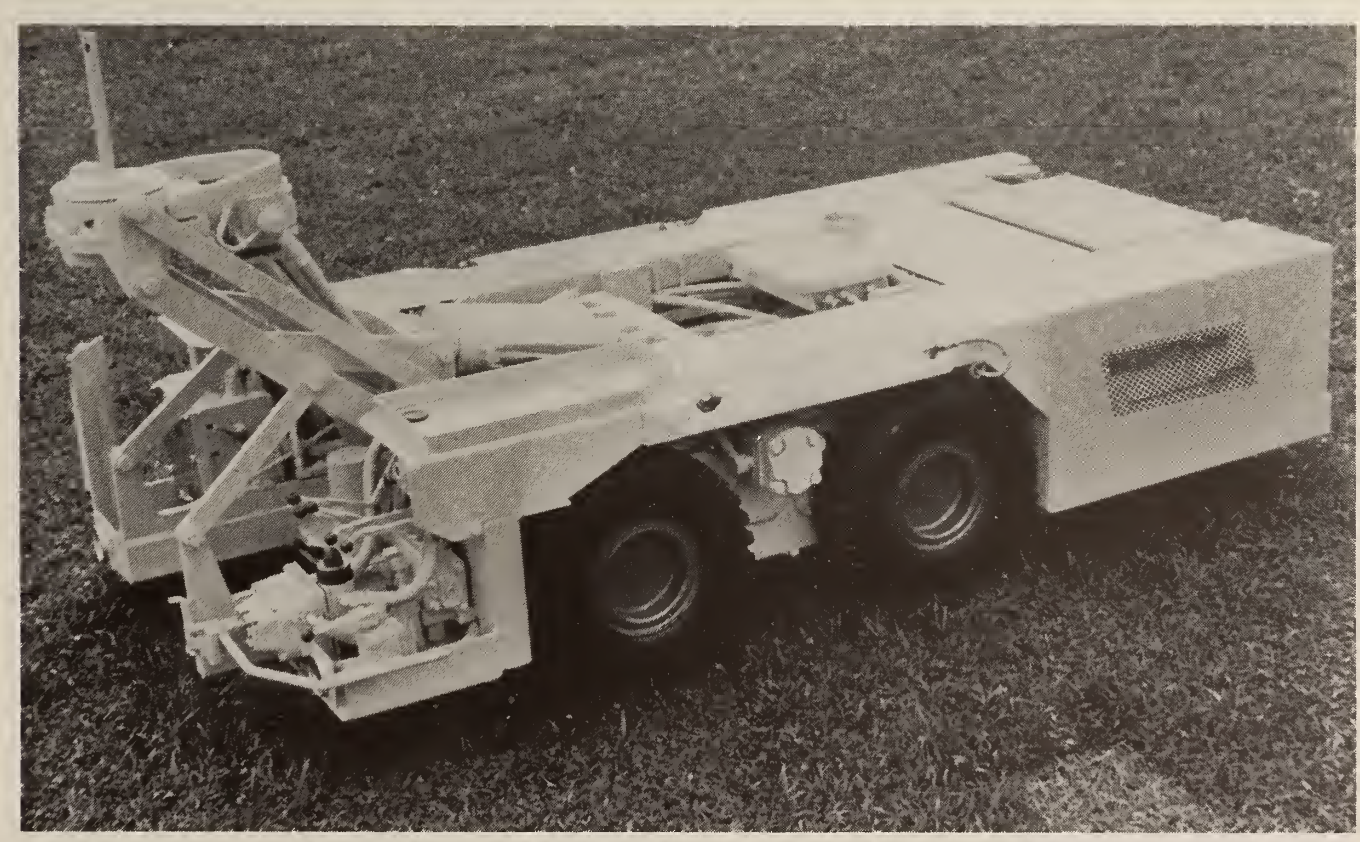

FIGURE 1. - Standard Fairchild roof bolter without ATRS.

this process. The ATRS system is now being fitted to the newest version of the Fairchild bolter, whose extended head is capable of reaching 46 in in height.

OPERATION OF THE ATRS

The ATRS is mounted on a stand and carried by a lift arm weldment on the drill head of the bolter. First, the operator positions the ATRS stand just inby the area to be bolted, lowers it to the bottom by lowering the drill head, and raises the ATRS jacks against the roof (fig. 2). Each jack is capable of supporting the roof load required by the West Virginia Department of Mines (11,250 lb) without adversely affecting the fragile roof strata. The ATRS must pressurize against the roof before the drilling and bolting controls become operational.

The operator then moves to the drilling and bolting controls, backs the machine away from the ATRS (figs. 3-4), and folds back the lift arm weldment, thus giving free access to the drill head. If the ATRS has been efficiently positioned in the entry, two bolts can be installed (5-ft maximum spacing) without repositioning the stand. To move the stand, the operator folds out the lift arm weldment, positions it under the stand, and lowers the ATRS jacks to the desired tramming height. He then raises the drill head to pick up the stand and maneuvers the bolter until the ATRS is repositioned (fig. 5). He repeats this sequence until the entire place is bolted according to the approved mine bolting plan. A cab and canopy at the rear of the bolter protect the operator as he trams from place to place (fig. 6).

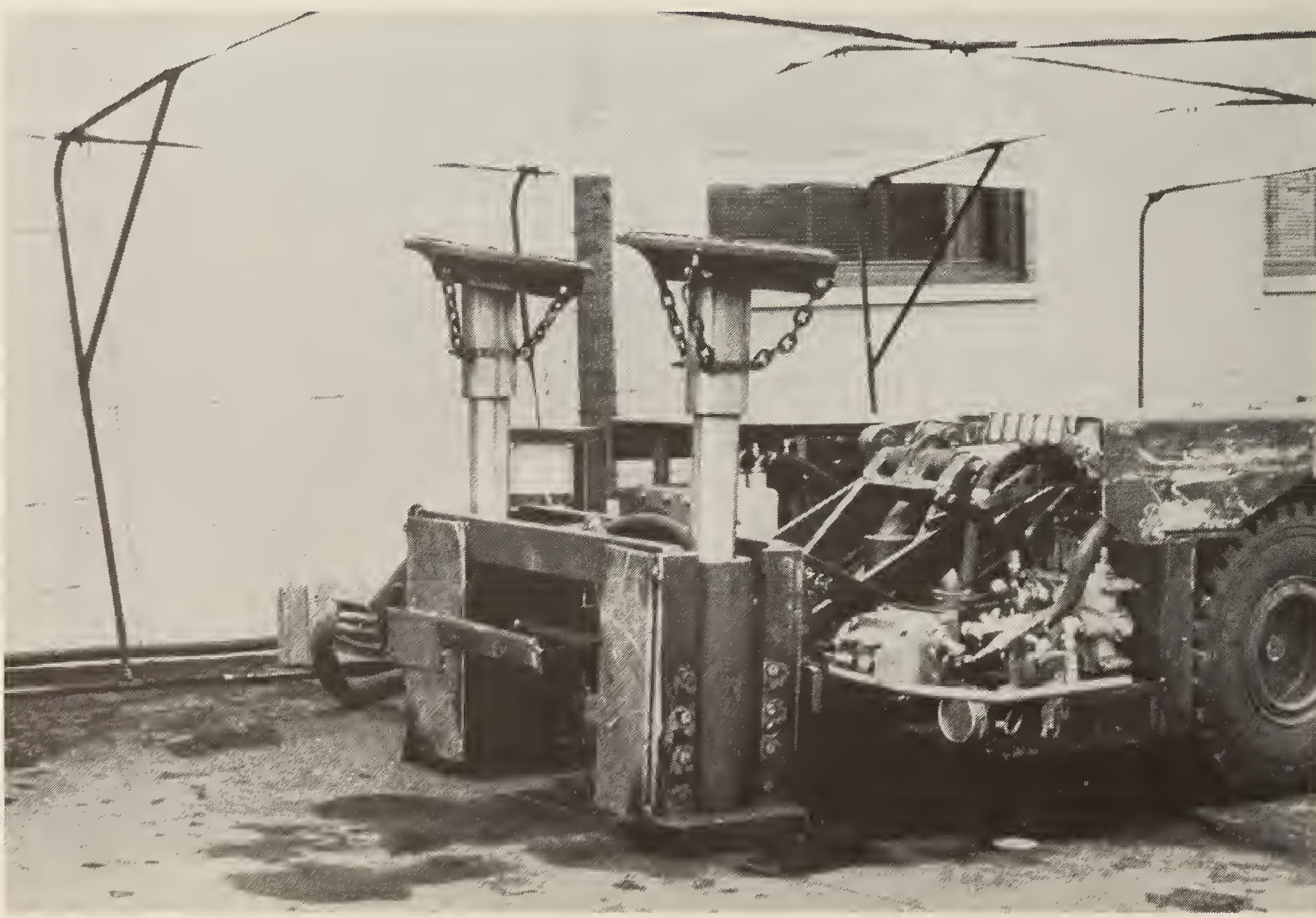

FIGURE 2. - ATRS jacks extended.

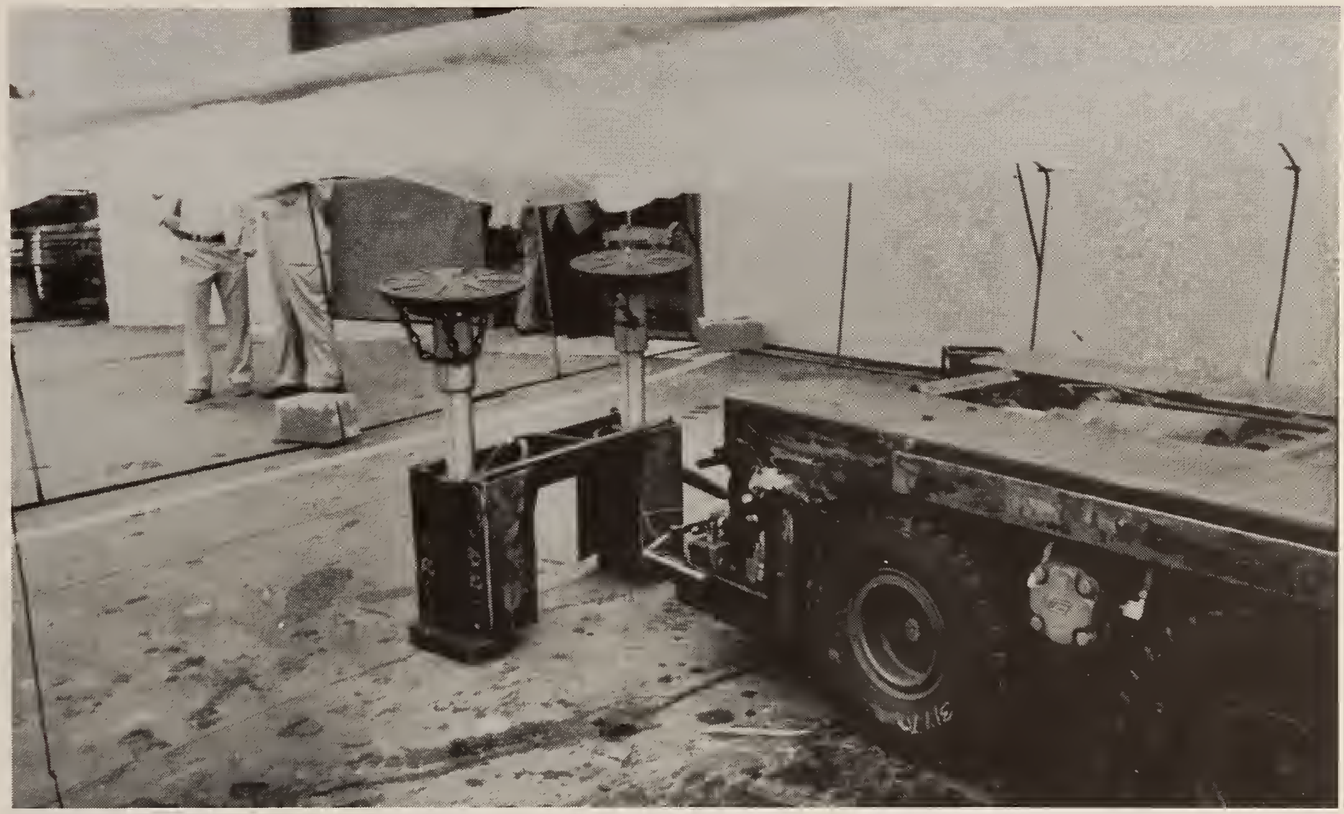

FIGURE 3. - Rear view of bolter backing away from ATRS stand.

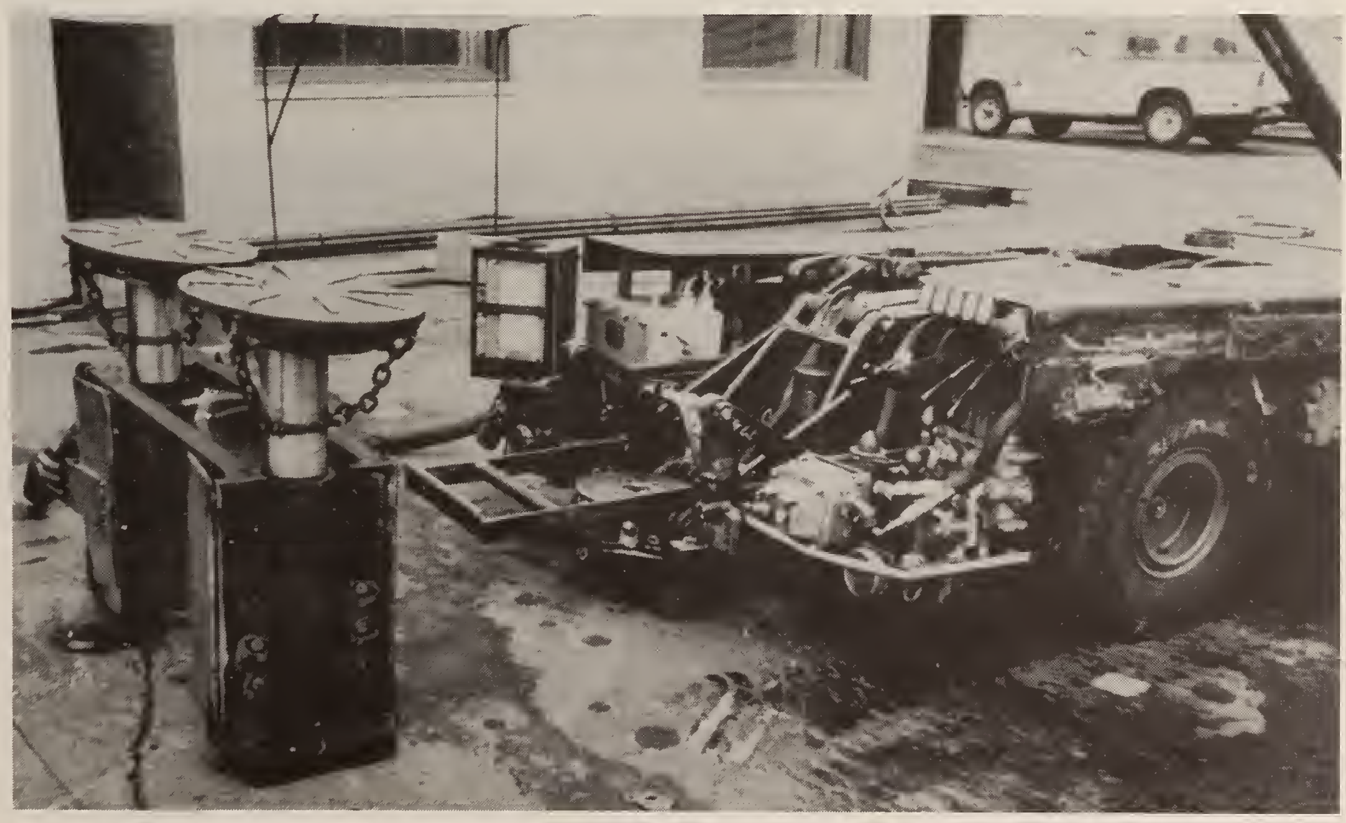

FIGURE 4. - Front view of bolter backing away from ATRS stand. Note lift arm weldment.

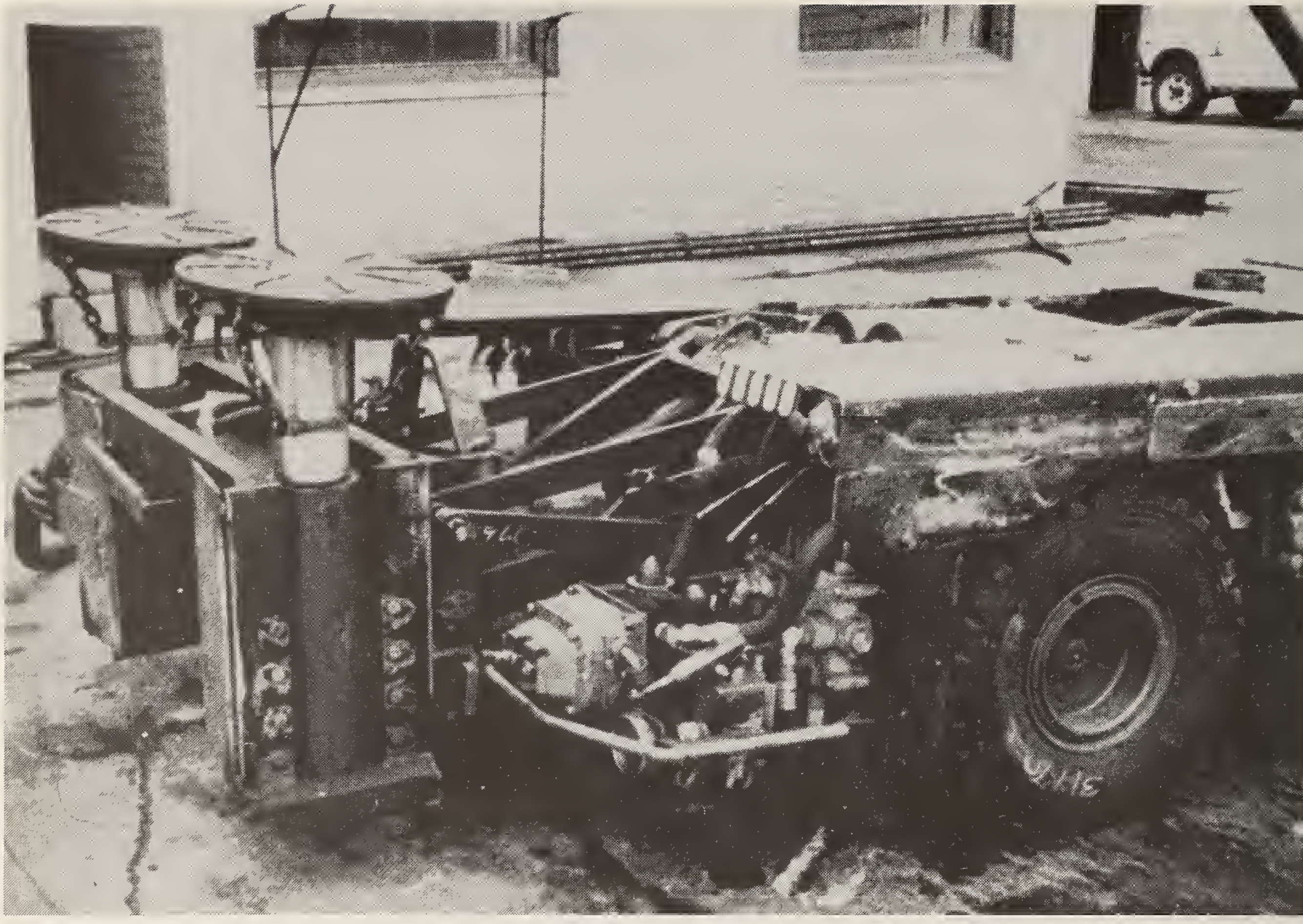

FIGURE 5. - Lift arm weldment repositioned beneath ATRS stand.

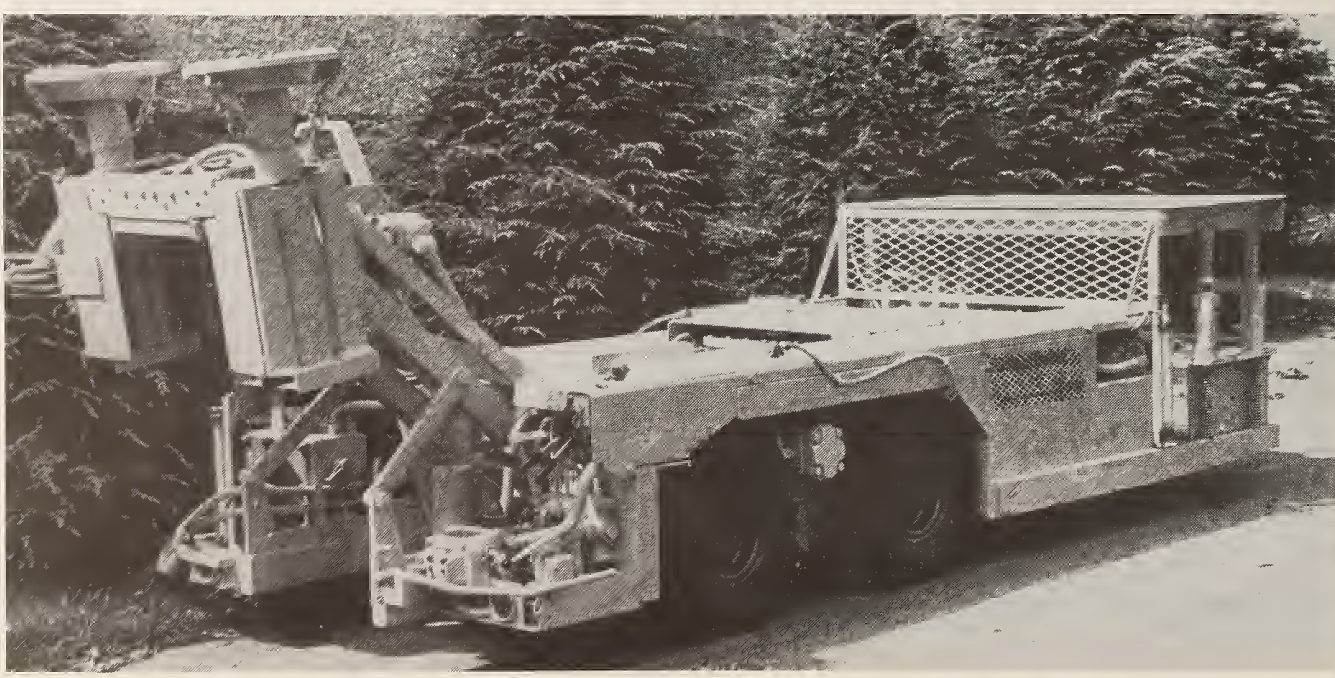

FIGURE 6. - Boom raised to carry ATRS. Note tram compartment at rear.

STATUS OF THE PROGRAM

A second underground trial is scheduled during May 1983. This should allow us to finish the research and begin full development of the new ATRS system. Although West Virginia is the first State to require ATRS systems, we believe other States will eventually require them. Therefore, the Fairchild ATRS system is being designed to achieve compliance with regulations while providing the maximum amount of safety, flexibility, and production. We believe we will be able to offer an ATRS retrofit kit to all West Virginia customers by March 1984.

RETROFIT ATRS SYSTEMS FOR ROOF BOLTERS

By Gary O. Bledsoe[1]

INTRODUCTION

G. O. Bledsoe, Inc., is a small engineering firm providing services to industry, commercial development, contractors, mining, and the general public. We provide professional engineering services on canopies and ATRS systems to various manufacturers and are most heavily involved with A&M Welding and Manufacturing Co., Inc., Mullens, WV, in research and development of retrofit packages for ATRS systems.

G. O. Bledsoe, Inc., is in a rather unique position because we do not represent a manufacturer and are primarily concerned with the retrofit industry instead of new equipment. For this reason we can look at a variety of designs without having to sell a particular product line. In the development of ATRS systems, we have tried to standardize as much as possible; however, we found this to be very difficult because almost every retrofit is a custom design package for each manufacturer's equipment and each variation of each model. This paper discusses the advantages and disadvantages of all four types of retrofit ATRS systems available today.

CHARACTERISTICS OF RETROFIT ATRS SYSTEMS

A good retrofit ATRS system should be (1) rugged enough to withstand roof loads and lateral impacts, (2) as light as possible to improve maneuverability, (3) versatile enough to meet a variety of roof conditions, and (4) easy to operate and maintain. Also, to satisfy ATRS regulations, the retrofit system must be designed such that the machine operator is always under permanently supported roof while installing the ATRS, and the hydraulic ATRS support jack(s) must contain a pilot check valve(s) to prevent accidental collapse. Unfortunately, many existing roof bolters were not designed to accommodate ATRS structures. Furthermore, some machines with ATRS systems were not designed to meet the requirements of the ATRS regulations now in place. Therefore, many existing machines will have to be modified in some manner to achieve compliance.

Installing a retrofit ATRS system is not a simple matter of attaching a roof support structure to the bolter; the machine itself must be modified substantially to obtain a good, "legal" ATRS system. Possible machine modifications include (1) adding inch-tram and/or ATRS positioning controls, (2) relocating existing controls, (3) adding or modifying the tramming deck and canopy, (4) revising structural framework to support the ATRS structure, (5) adding newer, more powerful tram motors, and (6) general overhaul of the machine to obtain optimum performance. The cost of performing these modifications is often equal to or greater than the cost of the ATRS system itself.

TYPES OF RETROFIT ATRS SYSTEMS

RING-TYPE

Figures 1-3 show a typical ring-type ATRS system on a single-head roof bolter. Figure 1 shows the system deployed in a mine entry, and figures 2 and 3 show the system when it was first installed on the bolter in a rebuild shop. The ring in these figures is 36 in in diameter (smaller or larger rings can be used) and is centered around the point where the

[1]President, G. O. Bledsoe, Inc., Beckley, WV.

FIGURE 1. - Ring-type retrofit ATRS deployed in mine entry.

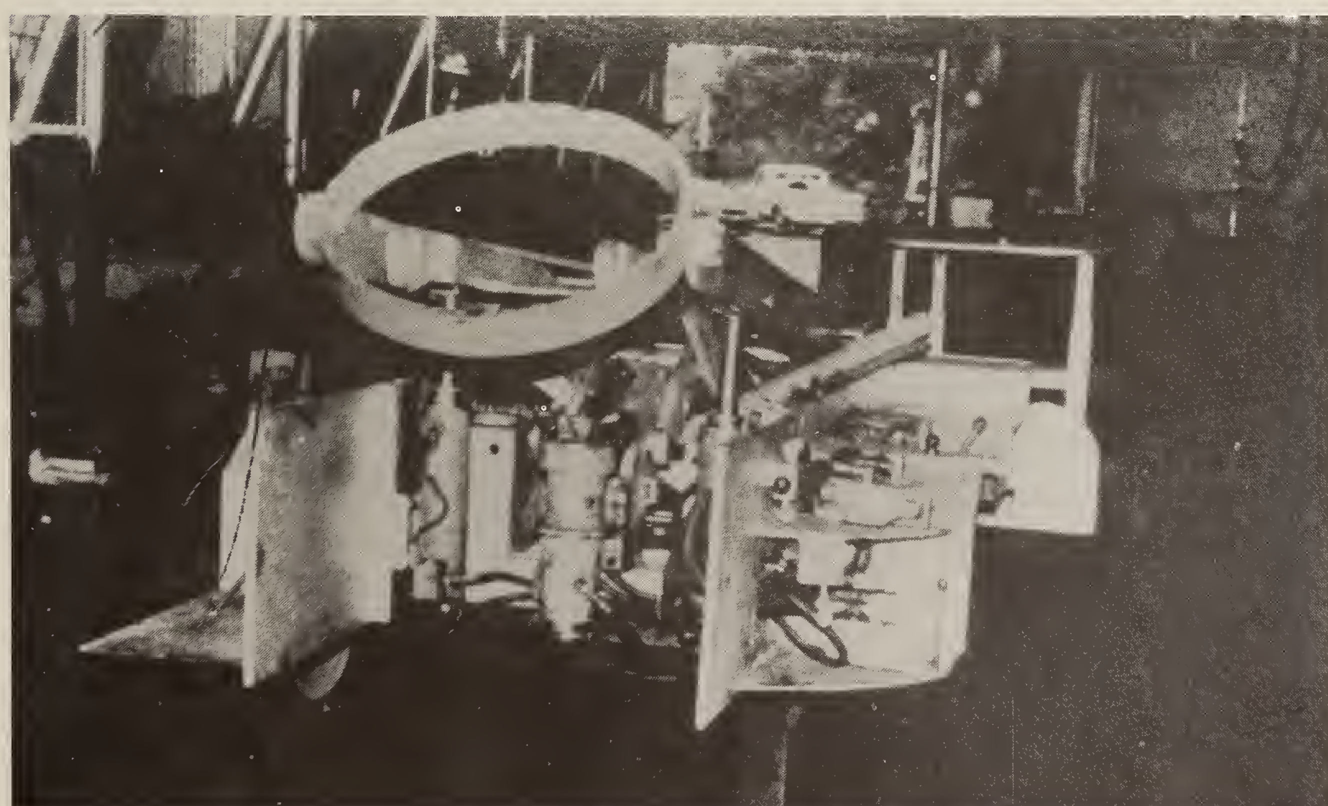

FIGURE 2. - Ring-type ATRS being installed in rebuild shop - front view.

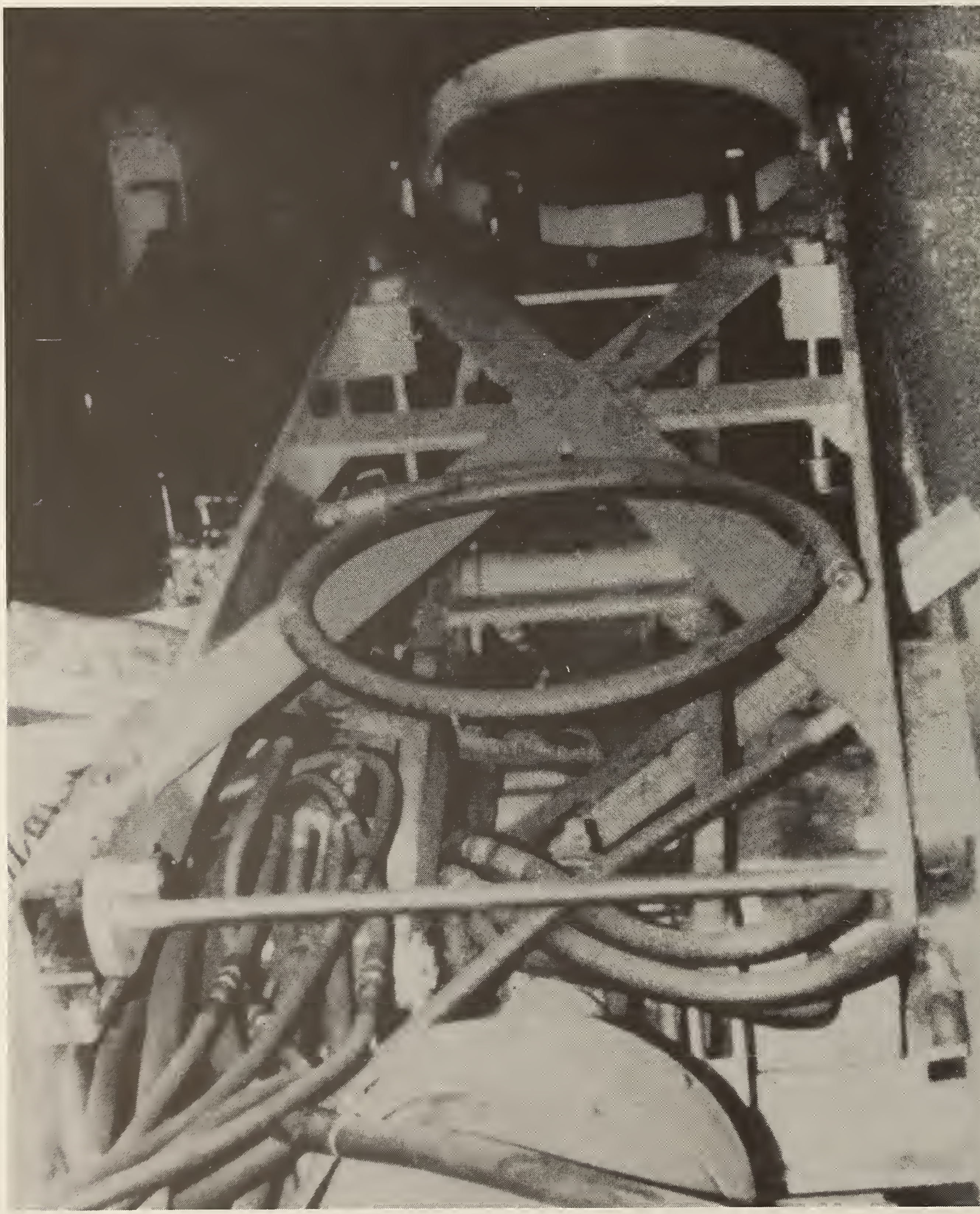

FIGURE 3. - Ring-type ATRS in rebuild shop - rear view.

drill steel enters the mine roof. The ring is mounted on a pair of steel arms and is raised to the roof by a hydraulic jack(s). It must be retracted and reset prior to each roof bolt installation because the ring only supports the mine roof in the immediate vicinity of each roof bolt hole.

Since the ring-type ATRS system is relatively small and maneuverable compared to other ATRS systems, many mine operators feel it is the best system available. However, one disadvantage of the ring design is that it usually contacts the roof at only two points; thus, high twisting stresses can occur in the support arms when the ring tries to conform to the irregular contour of the mine roof. The designs of some ring and support arm structures result in roof contact at only one point, further increasing the twisting stresses.

Installation of a retrofit ring-type ATRS system on a high-coal machine is rather simple--the support arms, pivots, and jacks can be welded directly on top of the machine frame. In low coal, however, the ring must often be dropped below the machine frame height, so the support arms and pivots must also be recessed below the frame. In most cases, this modification is quite difficult and expensive because the machine must be stripped down to its main frame to provide the necessary clearances. Ring-type retrofit ATRS systems appear to be applicable to bolters in seams as low as 32 in.

H-FRAME

Figures 4 and 5 show the H-frame retrofit ATRS system designed by G. O. Bledsoe, Inc., and fabricated by A&M Welding and Manufacturing Co. for single-head roof bolters. Although the H-frame, like the ring-type ATRS, was designed to support only the roof area in the vicinity of one bolt, we prefer it to the ring type because (1) the H-frame will usually contact the mine roof at three or four points, versus one or two for the ring type and (2) the cantilevered design of the H-frame allows it to support more roof area than the ring type (an 8- by 8-ft versus a 5- by 5-ft area). Figure 6 shows an alternative version of the H-frame design; in this case, the middle portion of the "H" in figures 4 and 5 is eliminated, and two separate hydraulic jacks are used to raise the remaining two portions of the roof support structure. This design provides more flexibility in uneven roof conditions than either the H-frame or the ring-type ATRS.

The H-frame and modified H-frame retrofit ATRS systems share two of the disadvantages of ring-type retrofit systems. First, the retrofit process is usually rather difficult and expensive, involving changes to the tramming station, bolter frame, and machine hydraulic system. Second, the H-frame has limited application to very low coal. Note that the H-frame structures in figures 4, 5, and 6 are made of 4-in-deep structural tubing that would increase the tramming height of the bolters unless special modifications were made. For this reason, G. O. Bledsoe and A&M Welding have developed a low-profile H-frame made of 1-in-thick steel plate, reinforced with stiffeners. The lowest tramming height attainable with the low-profile H-frame is approximately 32 in.

BAR-TYPE

Bar-type ATRS systems are different from ring-type or H-frame designs because the bar is usually designed to support the roof area normally supported by one complete row of roof bolts (sometimes two rows) rather than just one bolt. Because of this, many operators believe the bar-type system is inherently safer than any single-bolt system. In addition, the bar-type system can improve productivity because a complete row of bolts can be installed with each ATRS setup. Almost all newly manufactured dual-head roof bolters contain some form of bar-type ATRS system.

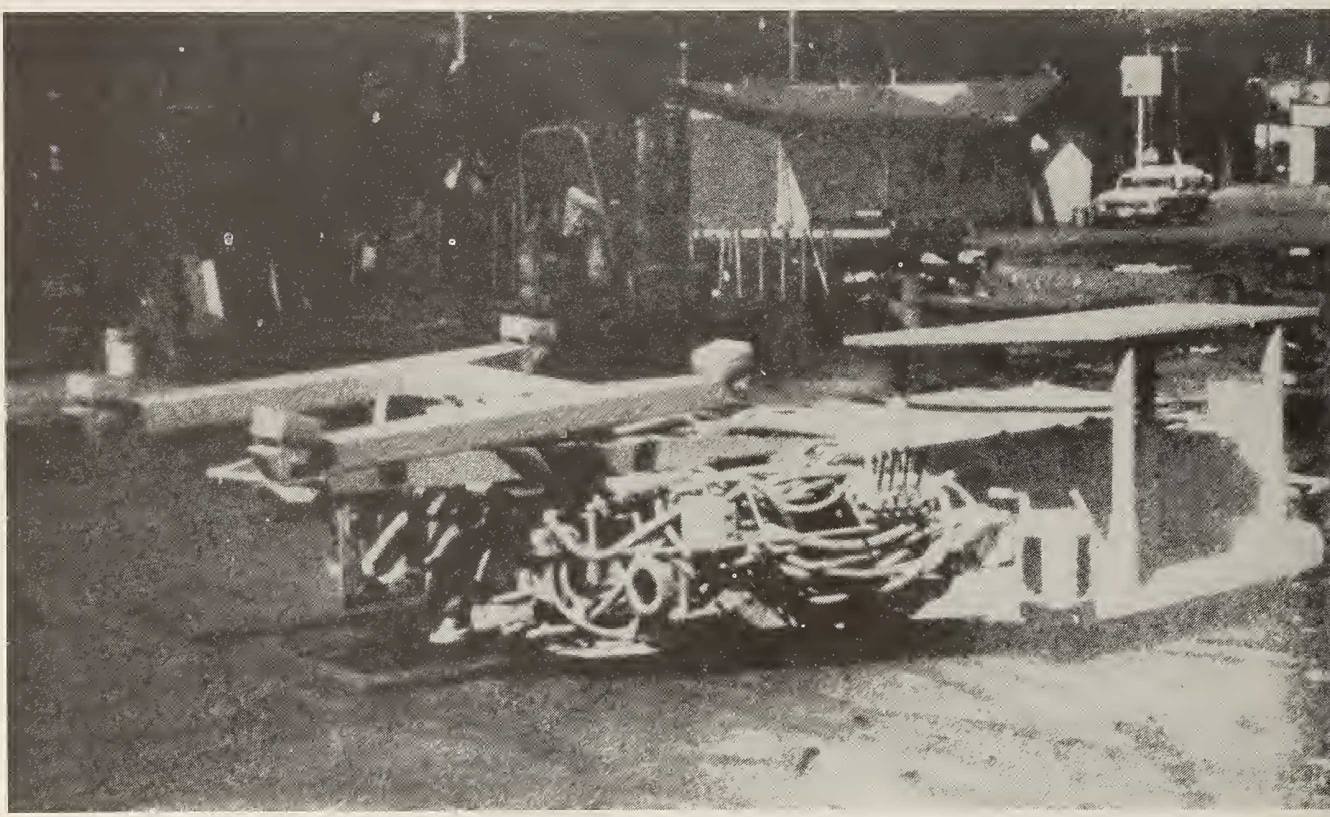

FIGURE 4. - H-frame retrofit ATRS on single-head bolter. Note streamlined control station.

FIGURE 5. - H-frame retrofit ATRS deployed in mine entry.

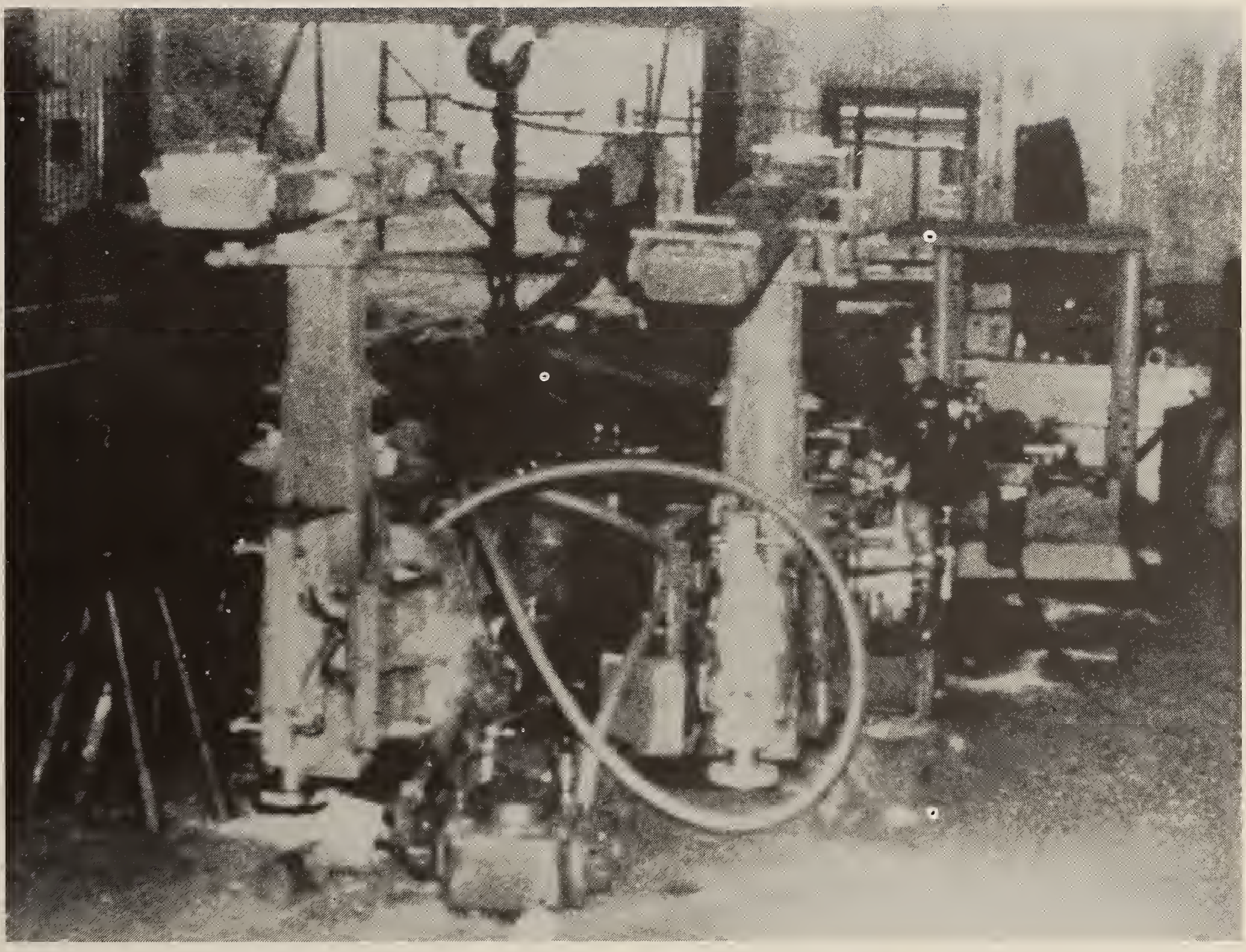

FIGURE 6. - Alternative H-frame ATRS - center portion removed.

In terms of retrofit, however, the bar-type ATRS system has some distinct disadvantages compared to ring-type and H-frame systems, especially with the small single-head bolters that are most likely to require retrofitting. Because the bar is usually heavier, bulkier, and cantilevered farther forward than either the ring or the H-frame, a bolter equipped with a bar-type retrofit system may be difficult to tram and maneuver around corners. The bar may also be difficult to set up in working places where the face and ribs do not form rectangular corners; this often occurs in conventional sections where the coal is blasted rather than cut from the face. The extra time required for these maneuvering tasks may totally negate the productivity advantages gained by the ability to install more than one bolt per ATRS set up. That is, if a ring or H-frame ATRS system is simple and responds rapidly, it could result in a faster overall bolting cycle time than a bar-type system. Furthermore, the heavier, bulkier bar often requires a far more difficult (and sometimes impossible) retrofit task than the other two methods. Thus far, only one retrofit bar-type system, designed by the Bureau of Mines, is now available to coal mine operators.

JACK-TYPE

The jack-type ATRS system is as simple as implied by its name--a single hydraulic jack (or a set of jacks) is thrust directly against the roof to provide support in the immediate vicinity of the

jack itself. Although its coverage is very limited compared to that of the other three types of ATRS systems described above, it is much simpler and can be retrofitted more easily to the bolting machines.

The primary application of the jack-type ATRS system thus far has been as a supplementary support, used in conjunction with a bar-type system. However, the jack-type system is probably the most appropriate system for very low coal seams because it lacks the ring, H-frame, or bar-type structures that require greater vertical clearance. The lack of a large load-bearing support structure on top of the jacks also makes the jack-type system less susceptible to machine-induced ATRS failure. That is, the upward thrust of the jacks on the ring, H-frame, or bar can sometimes induce stresses that exceed the rock load for which the structures were designed. Special care must be taken when designing these three systems to avoid excess upward thrust loads.

NEED FOR RETROFIT ATRS SYSTEMS

Considering that most of the single-head roof bolters now being used in southern West Virginia do not contain ATRS systems, a great deal of retrofitting work will need to be done in order to comply with the March 1984 deadline specified in the West Virginia ATRS regulation. G. O. Bledsoe, Inc,, and A&M Welding and Manufacturing Co. are in a position to help meet these needs because we have developed and installed retrofit ATRS designs for Fletcher, Lee-Norse, Acme, and FMC (Galis) roof bolters. About 30 pct of all retrofit ATRS systems now being used in the Appalachian coalfields have been designed and installed by our companies.

Mine operators must remember that simple retrofit kits for their machines are not sufficient; the systems must be installed by persons with intimate knowledge of both the ATRS requirements and the design of the roof bolter itself. In each case, the mine operator must decide whether to retrofit the existing bolter or replace it with a new machine designed specifically to accommodate an ATRS system.

Although retrofits are not cheap, they are less expensive than buying a new machine; on the other hand, a newly designed machine will often contain a neater, more advanced, and more maneuverable ATRS package. If capital is available, the new machine option is probably the best one to choose. Most small mine operators, however, will not be able to afford new machines; therefore, they should consider the advantages and disadvantages of each type of retrofit system very closely. It is hoped that this paper will help them make their decisions regarding retrofit ATRS systems.

THE SCHROEDER FRONTRUNNER ROOF BOLTER WITH ATRS SYSTEM

By Gus Schroeder[1]

The Frontrunner is a twin-head bolter designed to operate in coal seams from 55 to 84 in high. To allow the machine operators to work in the safest possible conditions, both operators are able to perform all functions associated with roof bolting, including tramming, from a single, well-protected position on the machine. The Frontrunner's design places the operators in two compartments located at the front of the machine (figs. 1-2). Each compartment is covered by a protective canopy that can be adjusted hydraulically to afford the maximum height within the compartment at all times.

During bolting operations, the primary operator protection is provided by an ATRS located directly in front of the operators' compartments. Drilling is done with a mast-type assembly which provides for hands-off drilling by incorporating both a deep drill chuck and a practical drill steel centralizer. The drill masts are located at the front of each operator's compartment (fig. 3) and can be shifted hydraulically across the full length of the compartment. The compartments themselves can be expanded laterally to a fully extended width of 185 in. Figure 4 shows the compartments in their fully retracted positions, and figure 5 shows the left compartment extended toward the rib. Because both the compartments and the drill masts can be adjusted laterally, a complete row of bolts can be installed without having to reposition the entire machine.

[1] Schroeder Brothers Corp., McKees Rocks, PA.

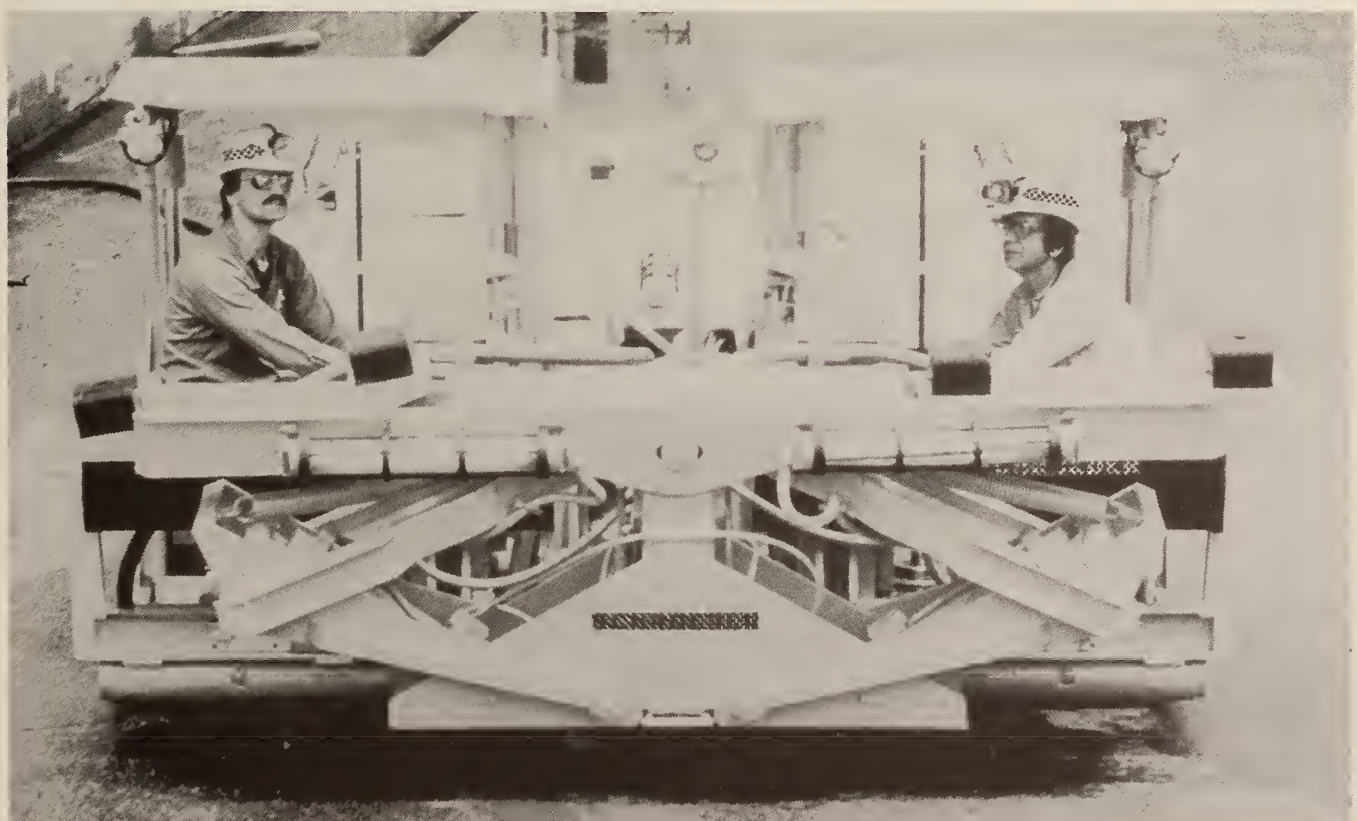

FIGURE 1. - Overall view of FRONTRUNNER roof bolter - ATRS lowered.

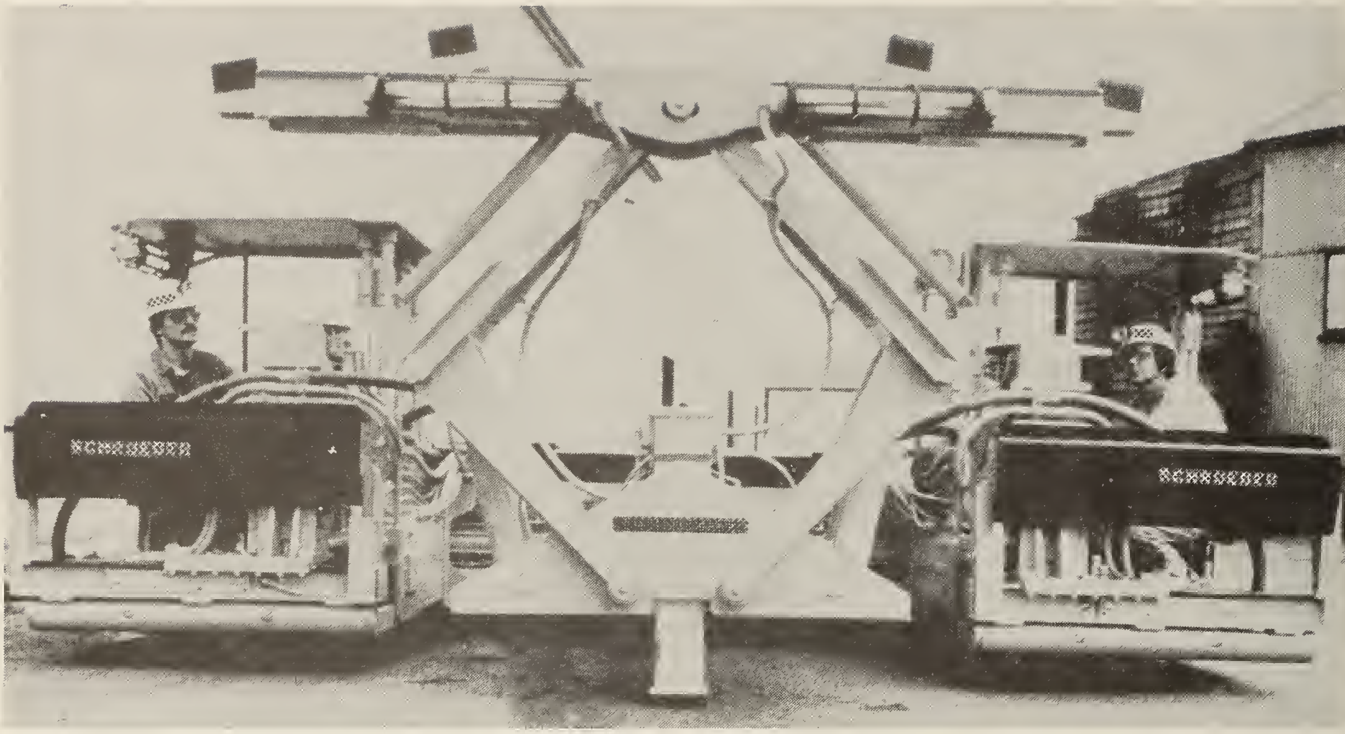

FIGURE 2. - Overall view of FRONTRUNNER roof bolter - ATRS raised.

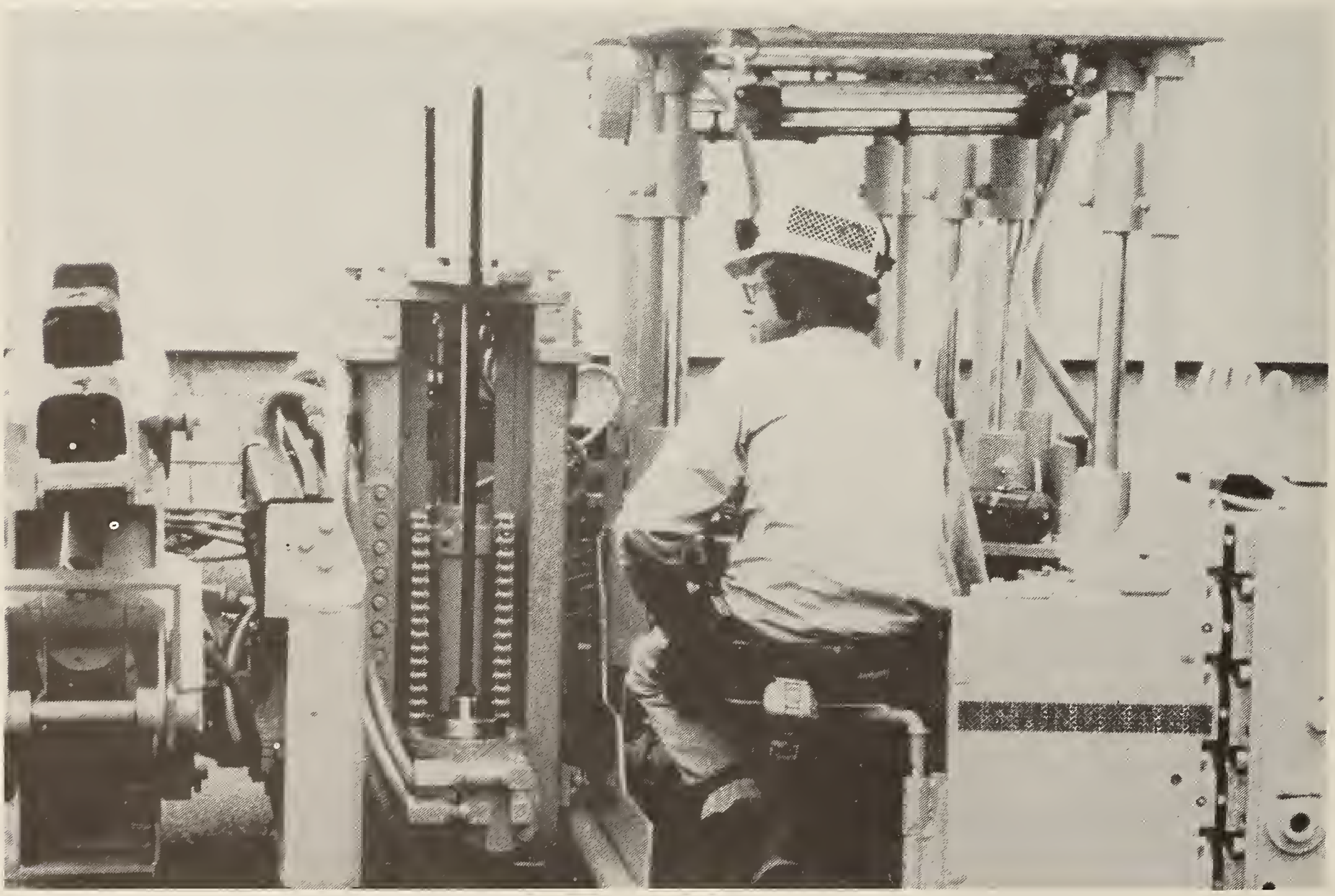

FIGURE 3. - Side view of sliding drill mast.

FIGURE 4. - Rear view - compartments retracted.

FIGURE 5. - Left compartment extended toward rib. Note tool tray.

The following sequence occurs during the normal installation of one set of bolts (four bolts per row). The operator trams the Frontrunner into the center of the working place and spots the drill heads for the first row of bolt holes. He then raises the ATRS to support the roof and lowers both compartments to the floor. The drill masts are then positioned inward for proper hole location, and the center two bolts are installed. The compartments are then repositioned outward toward the mine ribs, the drill masts are repositioned, and the outer two bolts are installed.

After the first complete row of bolts is installed, the operator slightly collapses the ATRS, trams forward to spot the drill heads for the next row, and resets the ATRS. During this brief period of repositioning, protection is provided for the operators by the canopies over each compartment. Because the operators always face one another within their compartments (fig. 6), each has full view of the other during both drilling and tramming. From their seated positions the operators can easily reach the drill heads in front of them and the tool trays behind them (fig. 5). Each tool tray is connected to the back of the operator's compartment and follows the compartment as it expands. Access to drill steels, roof bolts, and other necessary supplies remains convenient regardless of where the compartments are positioned. The design of the Frontrunner's operating compartments, therefore, provides a safe, efficient, and comfortable working environment.

Safety has also been a key consideration in the design of the Frontrunner's operating controls. Control levers (figs. 7-8) have been grouped together in logical relationship to the sequence of their function in the bolting cycle.

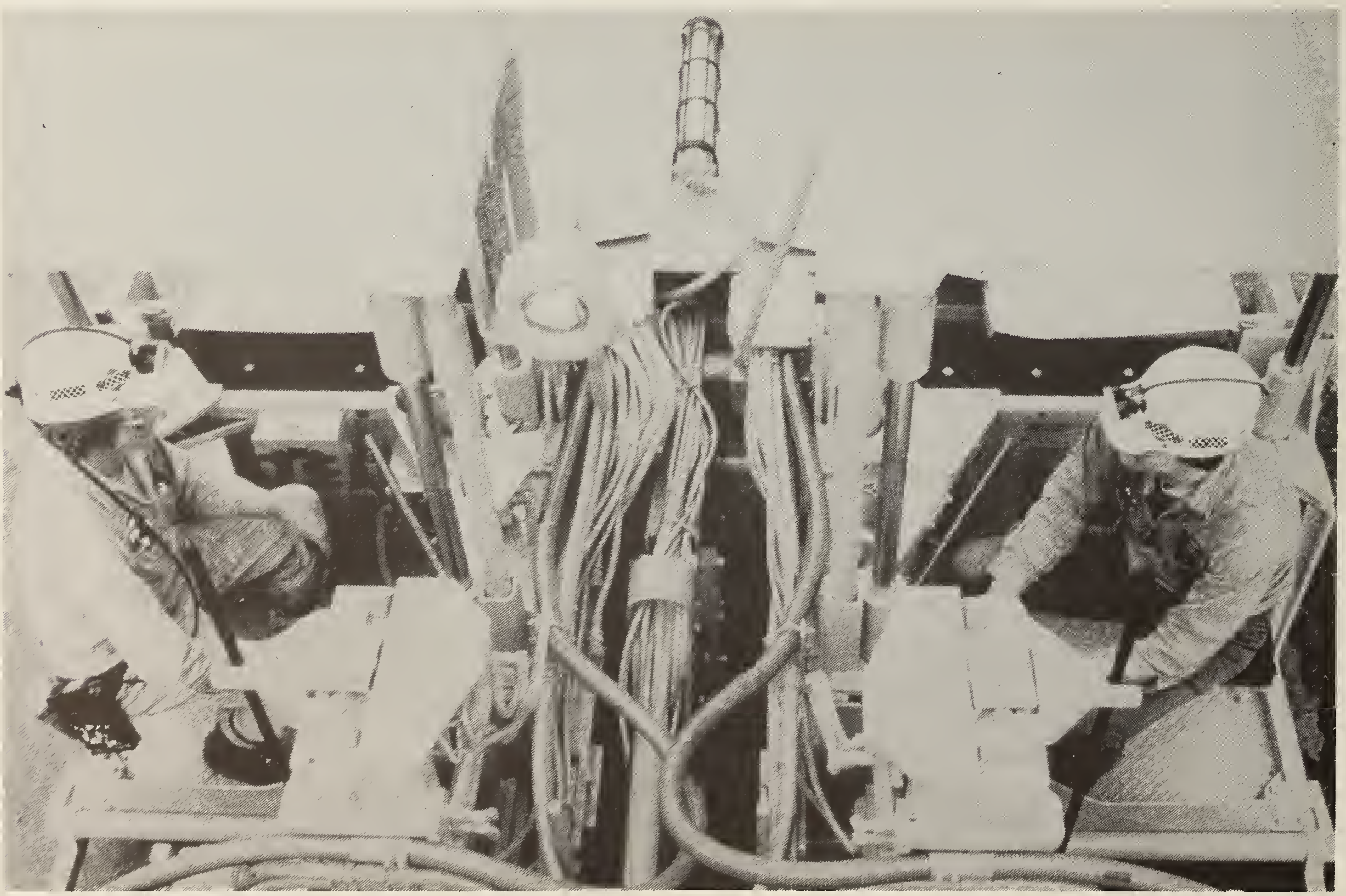

FIGURE 6. - Bolter operators maintain visual communication during bolting cycle.

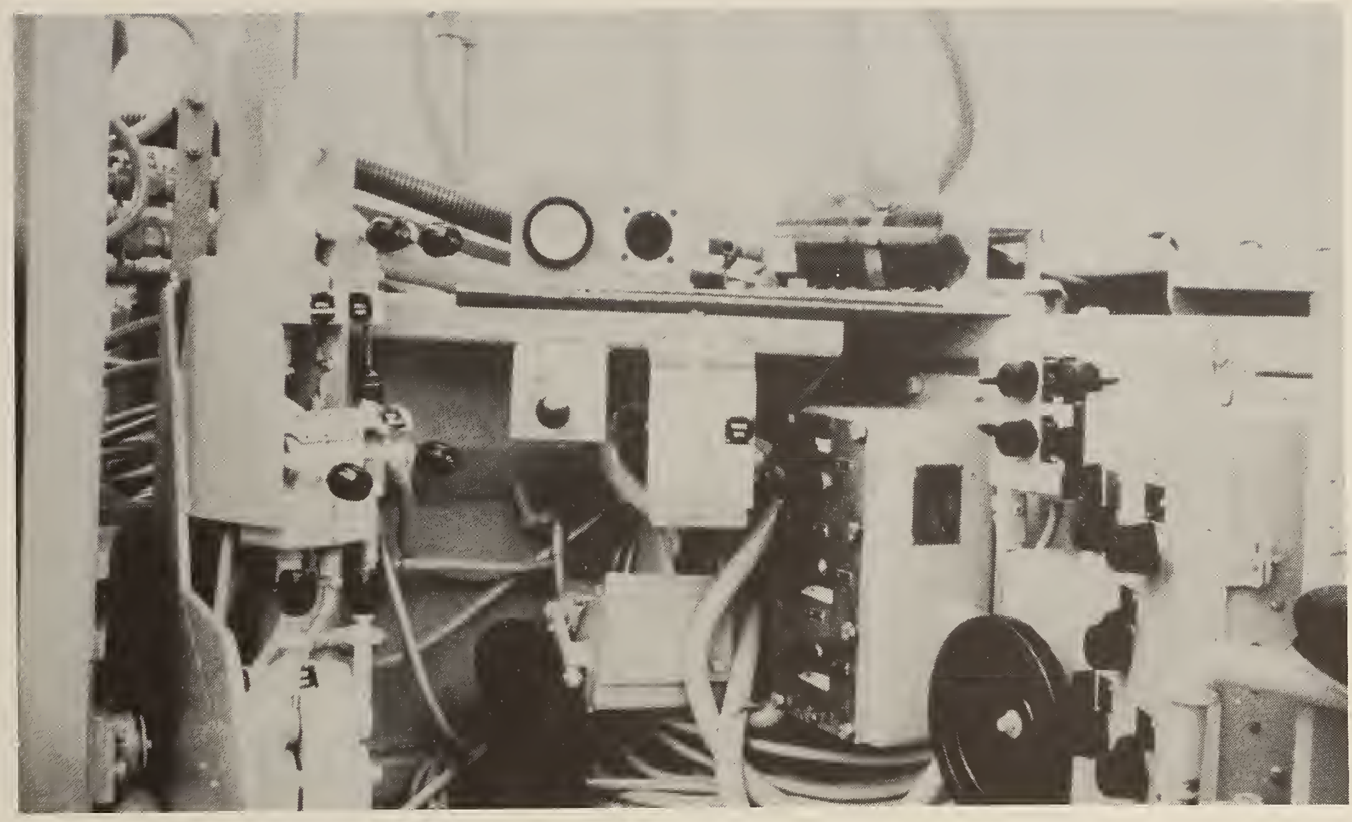

FIGURE 7. - Control layout within operator compartment.

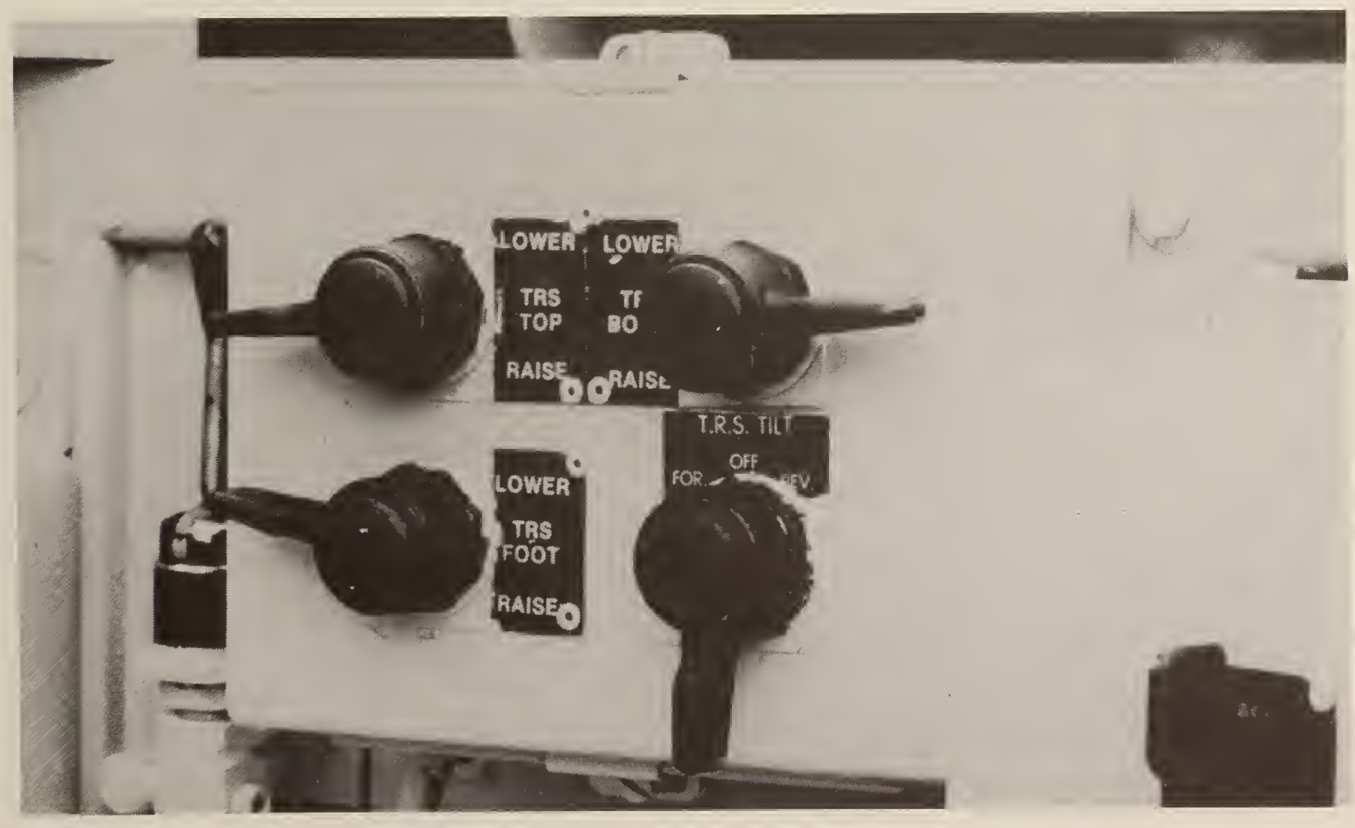

FIGURE 8. - Closeup of ATRS controls.

Maximum speeds of the various functions have been set at levels that allow the operator to maintain control of the machine. The left side operating compartment contains the primary control system with individual controls for (1) tramming, (2) raising and lowering the ATRS, (3) moving the left compartment, (4) raising and lowering the left side canopy, and (5) operating the left side drill head and mast. The right side operating compartment contains controls only for the right side drill head and mast, movement of the right compartment, and height adjustment of the right side canopy. Panic bars that stop all operations are conveniently located in both compartments.

To ensure that the Frontrunner can be trammed easily, the steering system is similar to that found in an automobile. Tramming speed is governed by a foot-operated accelerator which controls speed from 0 to 88 ft/min. Steering is accomplished with a steering wheel rather than the lever arrangement found on most mining machines. If the wheel is turned right, the machine turns right. If the wheel is turned left, the machine turns left. The turning radius of the machine becomes tighter as the wheel is turned. This automotive-type steering system allows even inexperienced machine operators to tram the machine safely.

Location of the operator at the front end of the Frontrunner affords maximum visibility while tramming forward. When tramming in reverse, he or she can obtain an undisturbed line of sight down the side of the machine by moving the left side compartment slightly out from the main frame. When the machine is in the tram mode, each operator retains the ability to raise and lower the height of his or her compartment and canopy to compensate for variations in seam height. When only one person is on the machine during tramming, controls for the right side canopy and compartment can be switched over to the left side compartment. The Frontrunner's design allows both operators to ride inside the protective compartments while the machine is moving from one working place to another. This feature reduces the possibility that the operators can become pinned between the machine and the mine rib.

Both the tram and ATRS functions on the Frontrunner can also be controlled remotely (fig. 9). A control box connected to the rear of the machine by an electrical cable allows machine positioning and setting of the ATRS to be done without either operator being physically located on the machine.

As stated earlier, the ATRS provides the primary protection against roof falls while the Frontrunner is in the drilling mode. When fully collapsed (fig. 10), the scissors-type ATRS is only 38 in high, which is less than the height of the machine frame. When fully expanded (fig. 11), the ATRS reaches a height of slightly over 9 ft. Use of the scissors-type ATRS design allows for about 6 ft of height variation in the ATRS without using telescoping hydraulic cylinders.

The ATRS is expanded by means of three double-acting hydraulic cylinders. The cross beam is raised and lowered by two cylinders which drive the scissors linkage arms. Hydraulic oil is furnished from a single control valve and then divided equally to each cylinder. A third cylinder, located in the main ATRS support housing, vertically lowers 1 ft from the housing to maintain ground contact (fig. 12). All three of these cylinders incorporate the required built-in pilot check valves.

The main support housing of the ATRS is mounted in a pivoted fashion on the boom, allowing the entire ATRS to be tilted by means of another hydraulic cylinder (fig. 13). This allows the ATRS to be adjusted to conform to the contour of each working face so that the last row of bolts can be installed as close to the face as possible. The ATRS boom itself can also be raised and lowered hydraulically. In

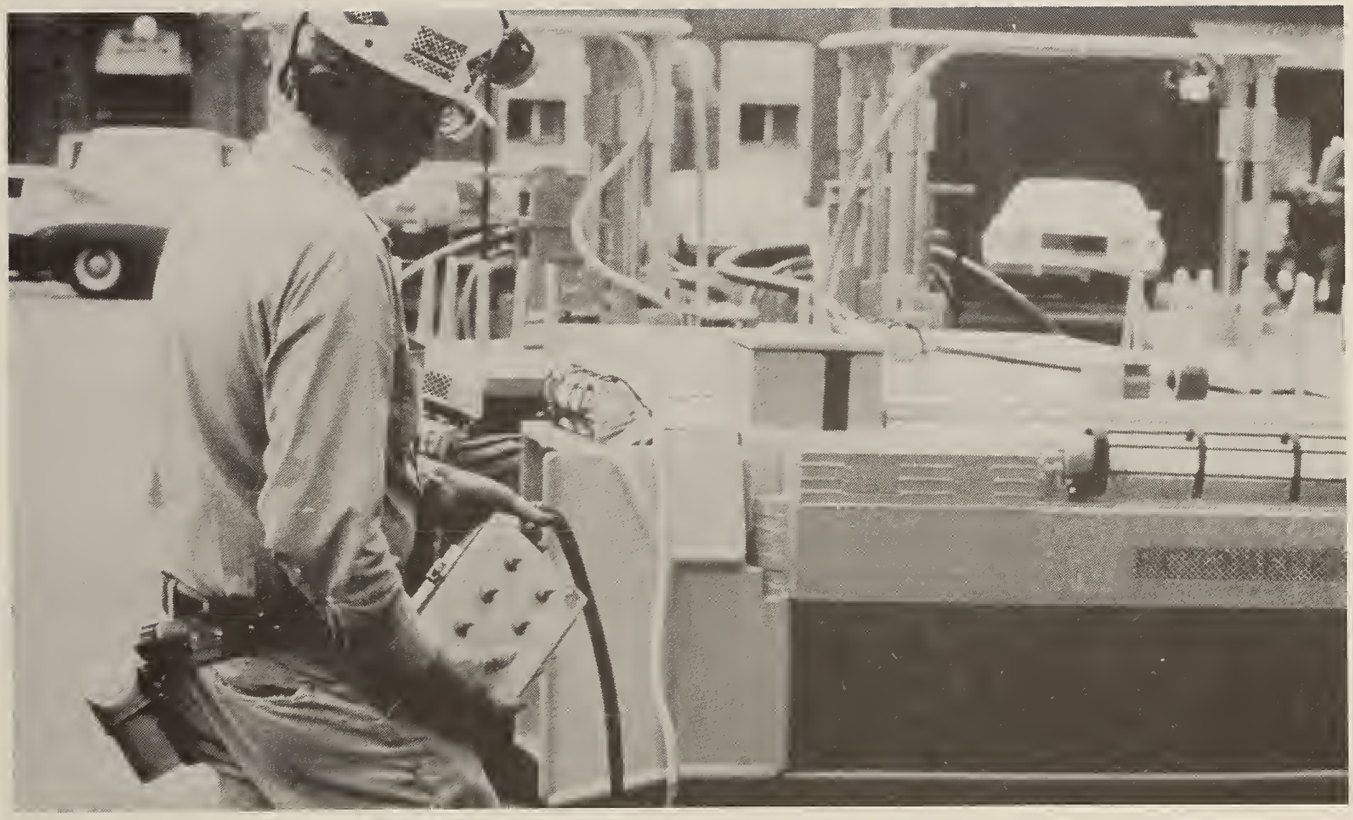

FIGURE 9. - Optional remote control tramming from rear of bolter.

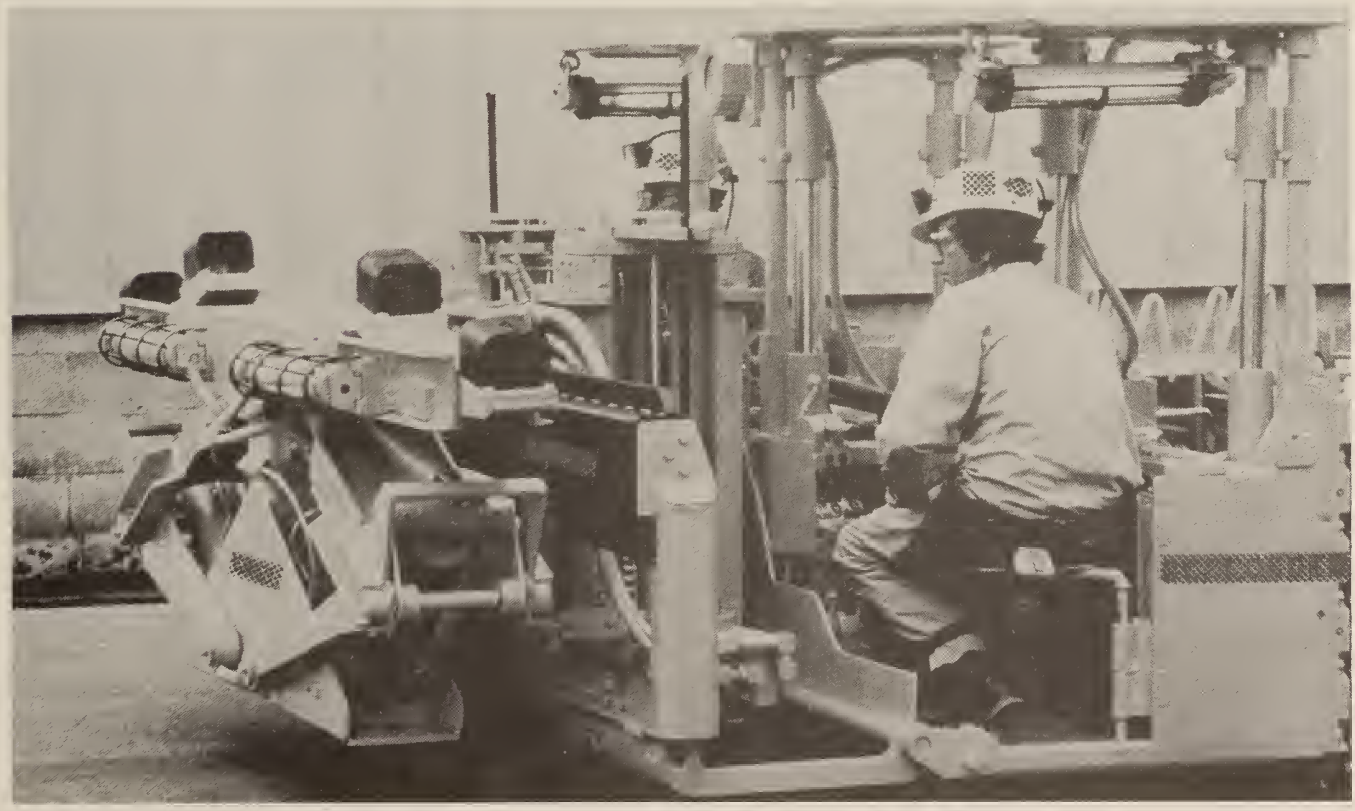

FIGURE 10. - ATRS collapsed - 38-in overall height.

FIGURE 11. - ATRS fully extended to 9-ft height.

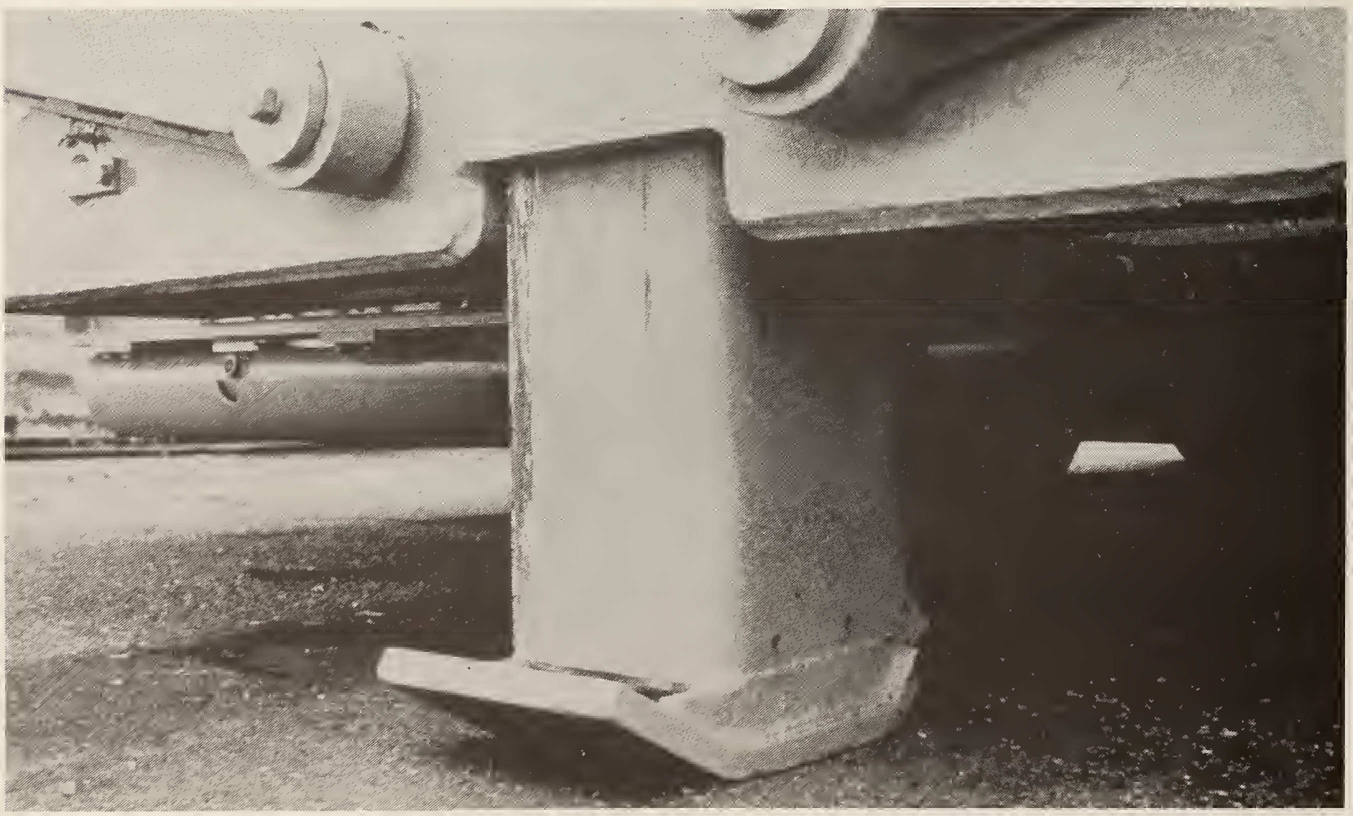

FIGURE 12. - ATRS stab foot maintains ground contact.

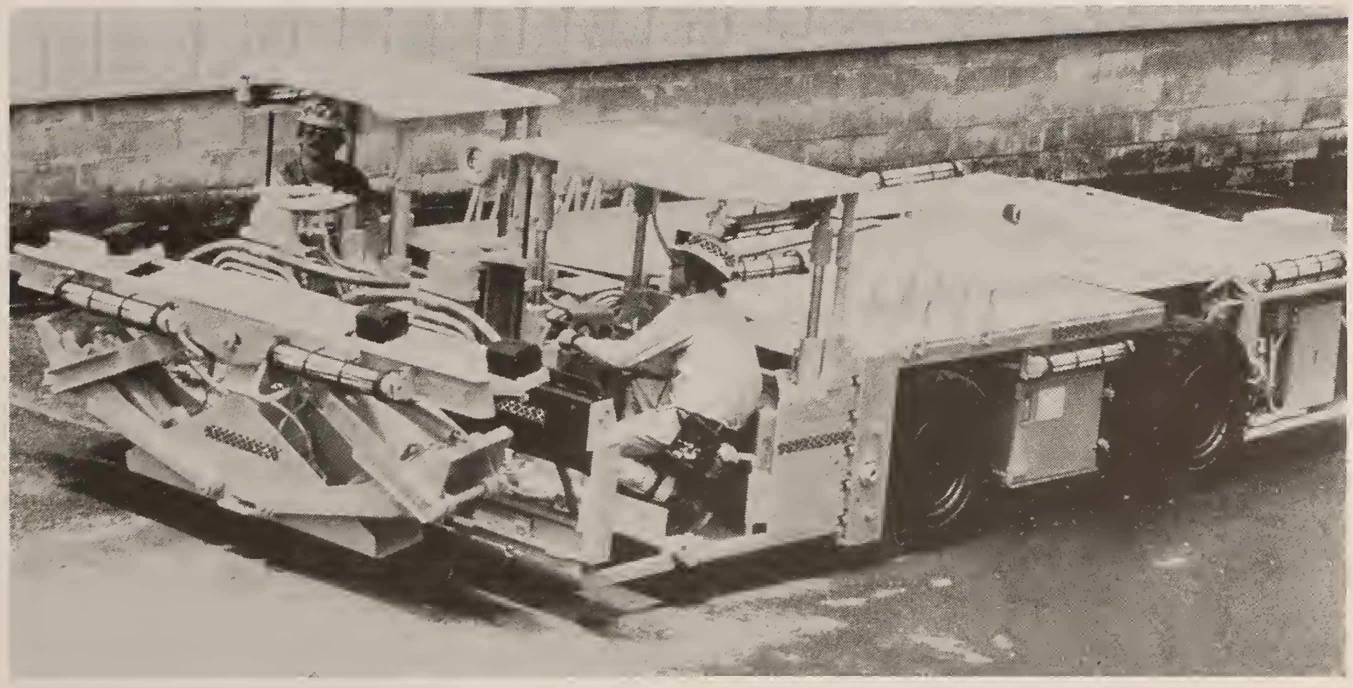

FIGURE 13. - ATRS beam tilted toward face.

total, four controls are used to operate the ATRS: boom raise and lower; ATRS tilt; ATRS foot; and ATRS expand and contract. The controls are grouped together in the left side operator's compartment.

Small rocker beams are located at each end of the main cross beam of the ATRS, and the cross beam itself is pivoted at the center. These features allow the ATRS to conform to the coal seam roof line. During periods when the ATRS is not set, the cross beam is maintained in a horizontal position by two large drop coil springs which run from the cross beam to the ATRS scissors arms. To prevent any overstressing of the ATRS assembly that might occur as a result of accidentally bumping the mine rib or roof while tramming, all the pivot points have been designed to have some degree of freedom of movement.

In summary, the major safety feature of the Frontrunner roof bolter is that its design allows both machine operators to perform all roof bolting functions, including tramming, from a single location on the machine. The use of two canopy-equipped operator compartments and an ATRS system provides protection for both operators at all times. Although our ATRS system was designed for use on the Frontrunner bolter, Schroeder Brothers may explore the possibility of adapting it to other dual-head roof bolters. Our ATRS system meets all applicable ATRS requirements outlined in the West Virginia Mine Regulations.

REMOTELY ACTUATED TEMPORARY SUPPORT (RATS) FOR FMC UNDERGROUND MINING EQUIPMENT

By Martin D. Wotring[1]

The 1969 Coal Mine Health and Safety Act required the installation of canopies on face equipment. Considerable opposition to the use of the canopies in low seams caused MSHA to waive the original canopy requirements in seams under 42 in. This left a large percentage of coal miners without any form of roof fall protection. An analysis of fatalities due to roof falls for 1972-75 revealed that roof bolters and their helpers suffer the largest percentage of fatalities (17.5 pct), and that setting temporary posts or jacks is the activity with the largest percentage of fatalities (18.5 pct). Of course, since the roof bolter and helper usually set the temporary support during the normal course of the bolting operation, these percentages indicated the need for some method to prevent a worker from going beyond permanent roof support to set these posts or jacks.

FMC first installed remotely actuated supports (RATS) on dual-boom roof bolters in 1974. This "ironing board" style RATS was used in place of the canopies over the drilling stations (fig. 1). At the 1976 American Mining Congress convention in Detroit, FMC displayed its first roof drill with a ring-type roof support (fig. 2) This was a single-boom drill that also incorporated a drill steel guide within the support and a canopy over the operator's deck. At the same time, ring-type and ironing-board-type RATS were being tried on existing single-boom drills as retrofit kits (figs. 3-4). Dual-boom roof bolters with ring-type RATS and drilling canopies (fig. 5) were also developed.

[1]Lead engineer, roof bolters, FMC Corp., Mining Equipment Division, Fairmont, WV.

Dual-boom roof bolters with beam-type RATS (fig. 6) became available in 1977. This type of RATS features four roof contact pads which are less than 5 ft apart. The pads swivel, as does a rocker arm to which the pads are connected. This permits the RATS to conform to uneven tops. The overall width of the beam-type RATS can be 8 to 10 ft. Figure 7 shows a beam-type RATS on a dual-boom drill designed for angle bolting.

FMC introduced a single-boom roof drill with a beam RATS at the 1980 American Mining Congress convention in Chicago (fig. 8). This machine has essentially the same type beam support as a dual-boom bolter, but the drill unit pivots horizontally to allow the installation of a complete row of four bolts on 4-ft centers. It has the capability to extend to allow the row of bolts to be installed in a straight line across the entry.

A single-mast drill was exhibited at the 1982 American Mining Congress convention in Las Vegas. This machine has space in the operator's deck for both the driller and helper, and both are covered by a canopy. The RATS is attached to the deck just ahead of the mast. The deck can be lowered to the floor and the RATS engaged against the roof for support, thus protecting both workers.

FMC has also been involved with two Bureau of Mines roof support research programs. One was to design, build, and test a lightweight, manually installed support jack (fig. 9). This jack is self-contained, is hydraulically actuated with a lanyard release, supports 22 tons, and weighs only 54 lb.

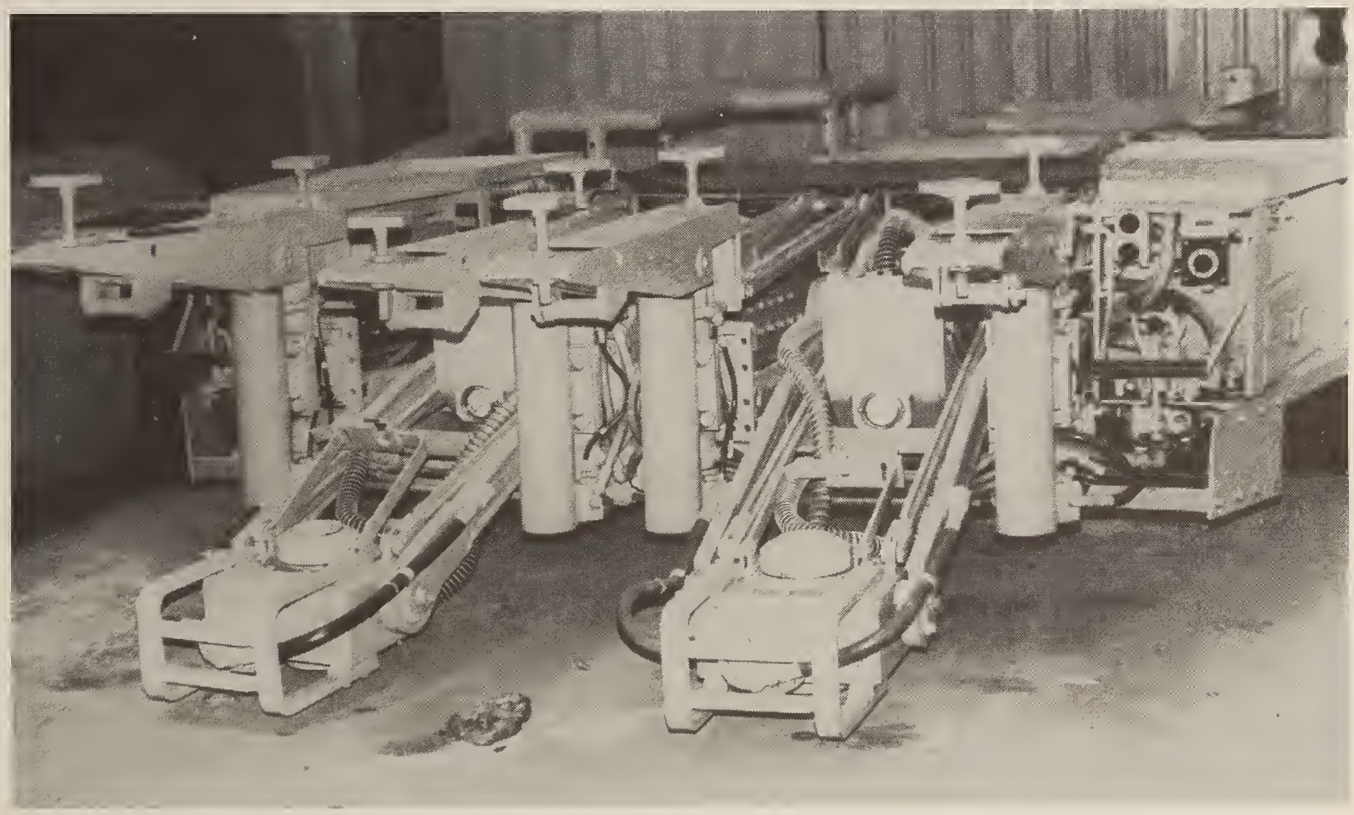

FIGURE 1. - Dual-boom roof bolter with ironing-board-type RATS.

FIGURE 2. - Single-boom roof bolter with ring-type RATS, operator's deck, and canopy.

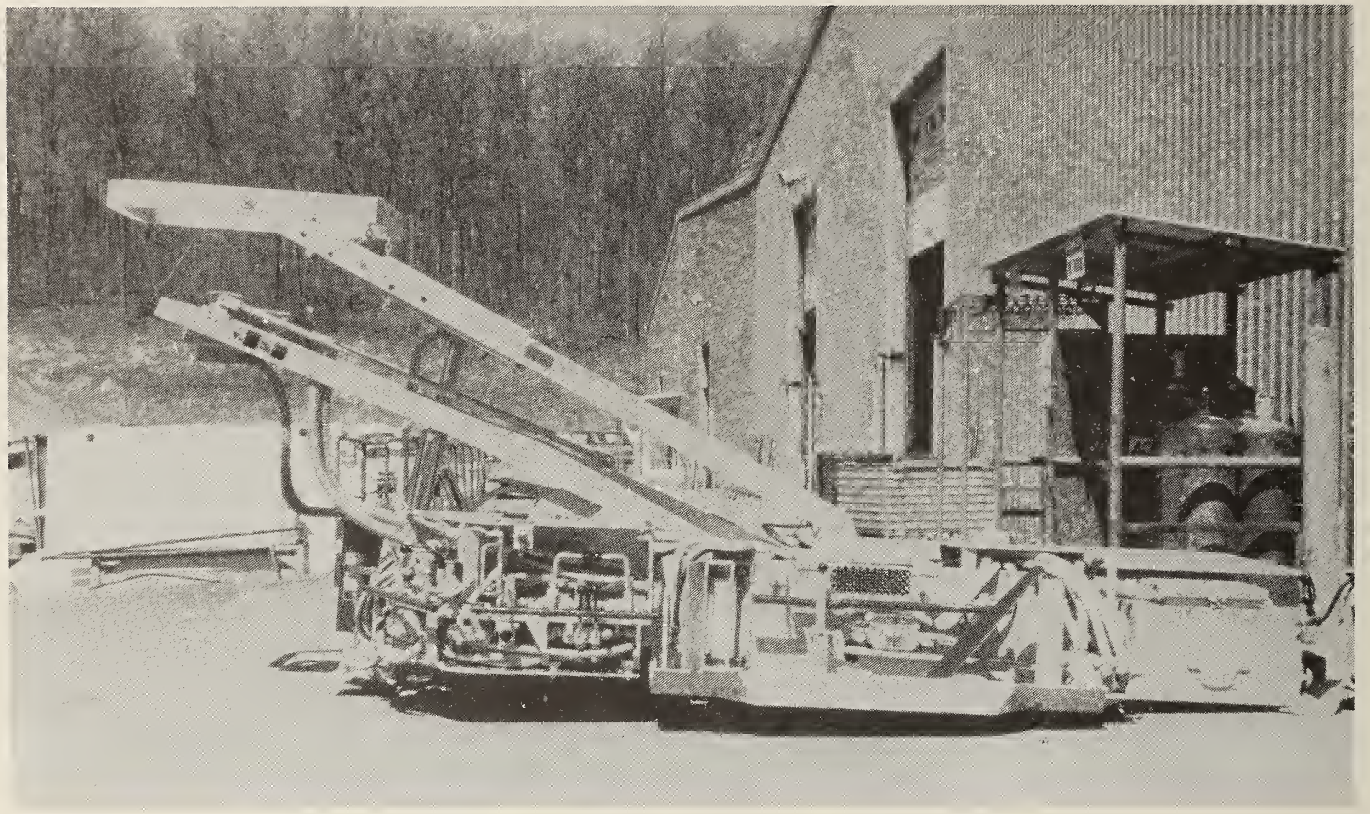

FIGURE 3. - Single-boom roof bolter with retrofit ring-type RATS.

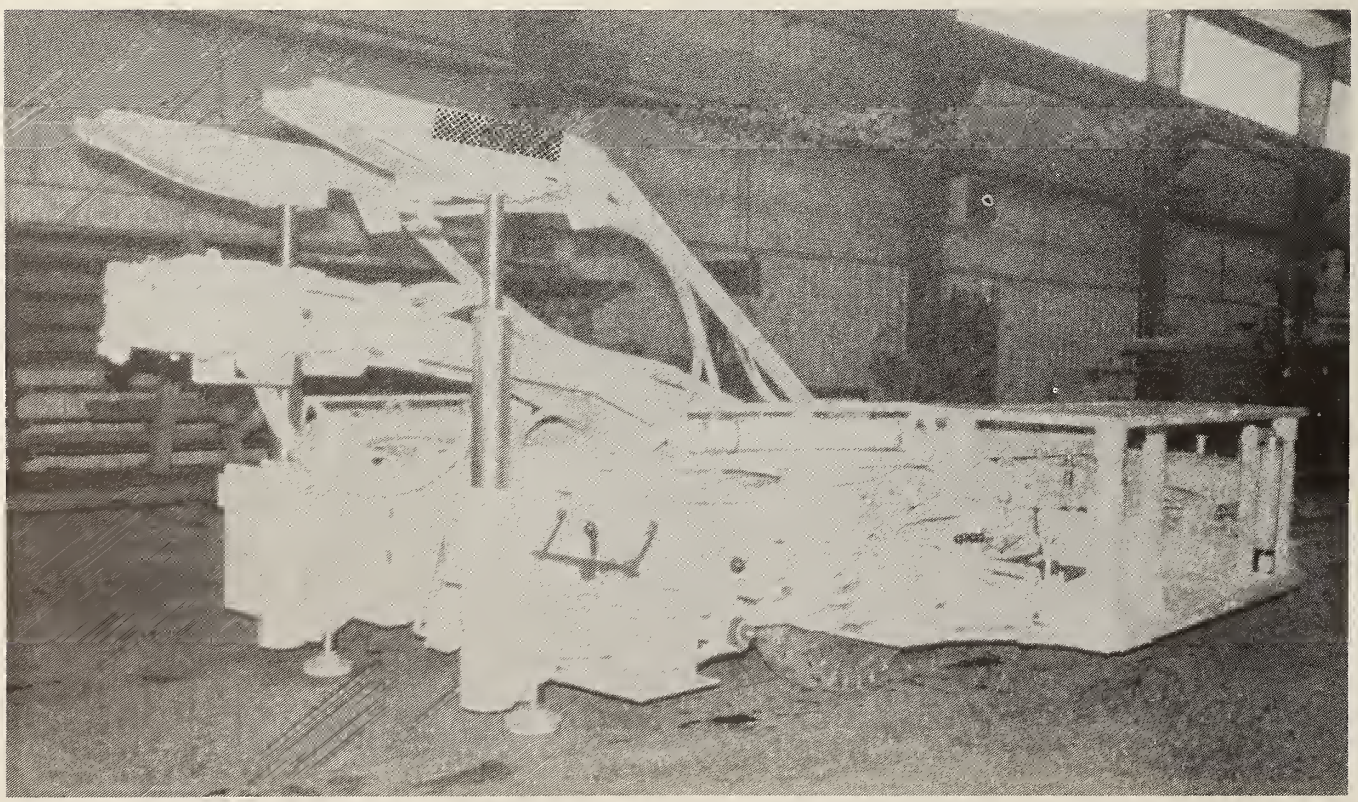

FIGURE 4. - Single-boom roof bolter with ironing-board-type RATS.

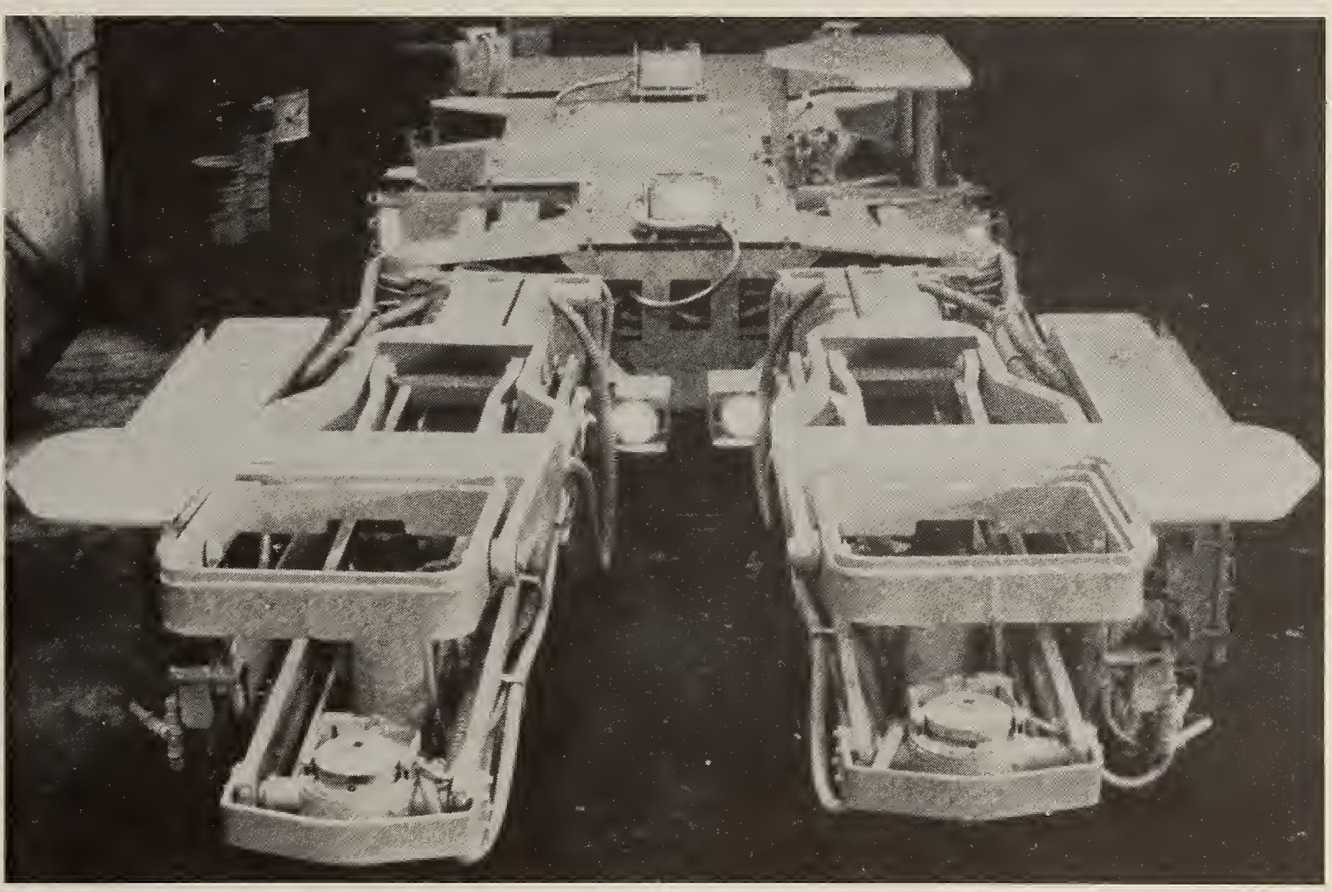

FIGURE 5. - Dual-boom roof bolter with ring-type RATS.

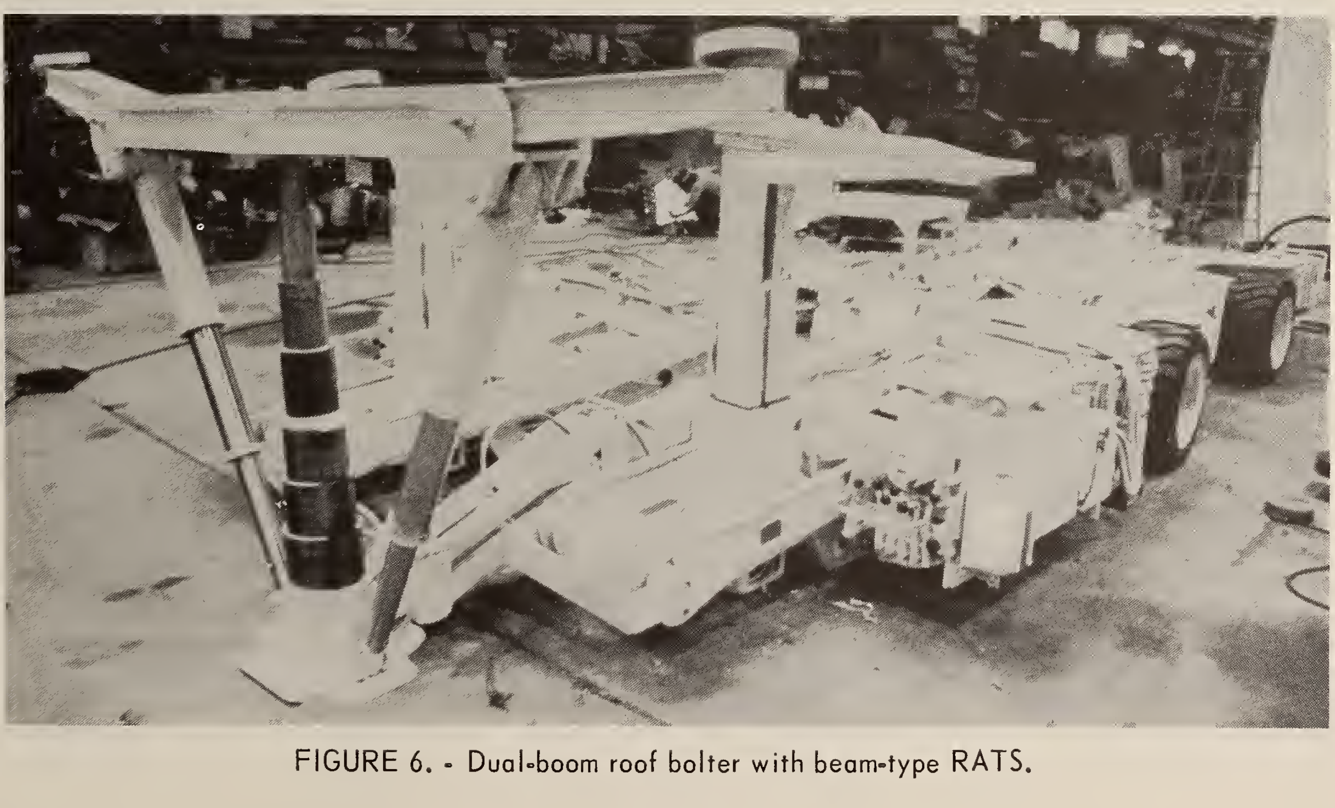

FIGURE 6. - Dual-boom roof bolter with beam-type RATS.

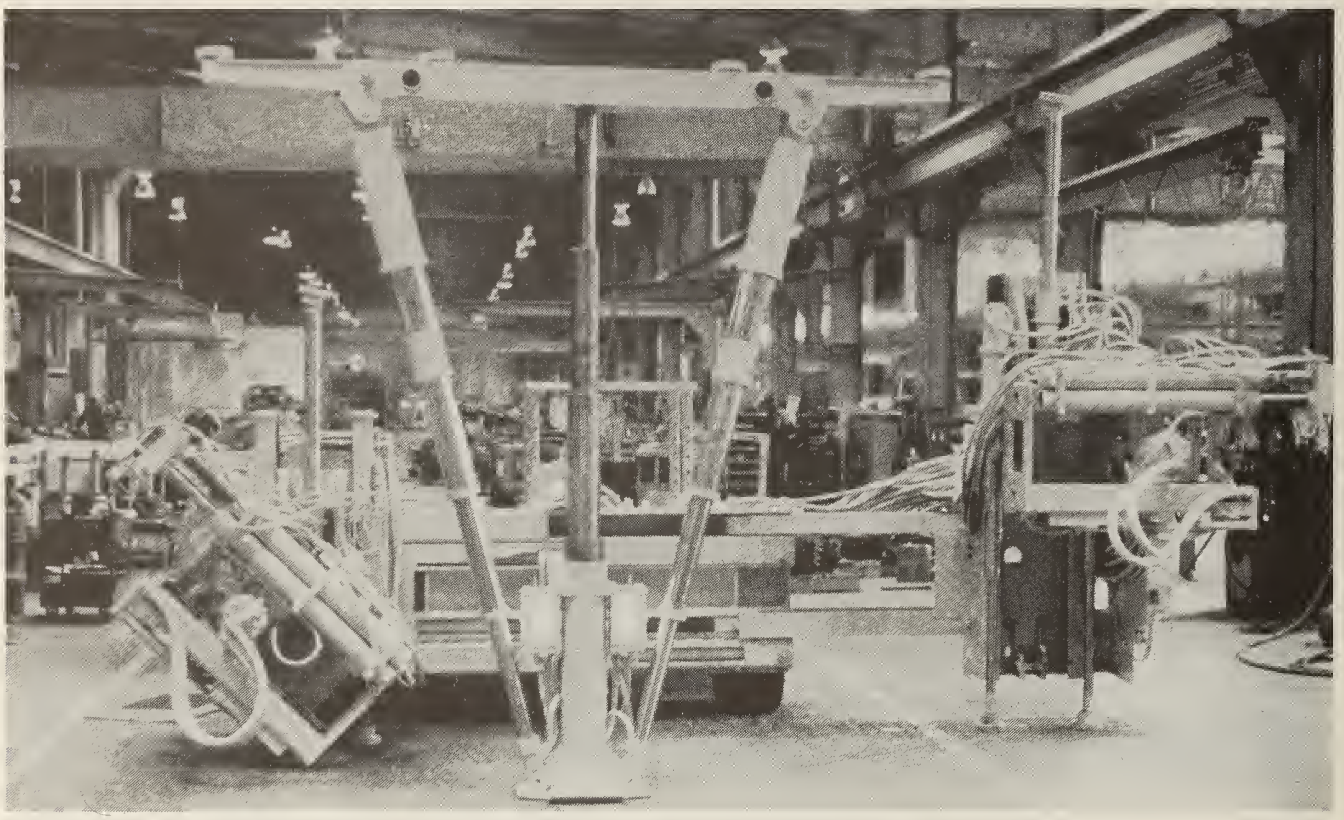

FIGURE 7. - Dual-boom angle bolter with beam-type RATS.

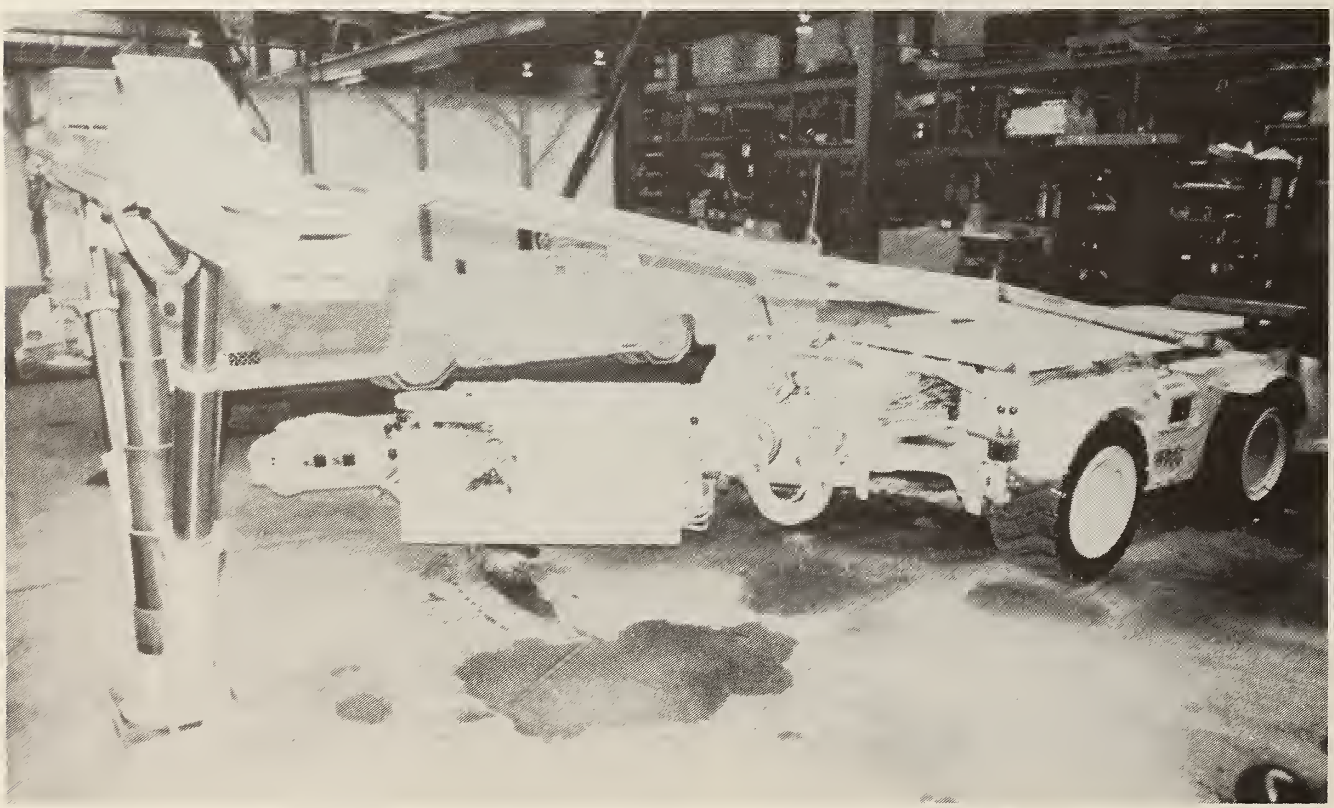

FIGURE 8. - Single-boom roof bolter with beam-type RATS.

FIGURE 9. - Lightweight temporary roof support jack.

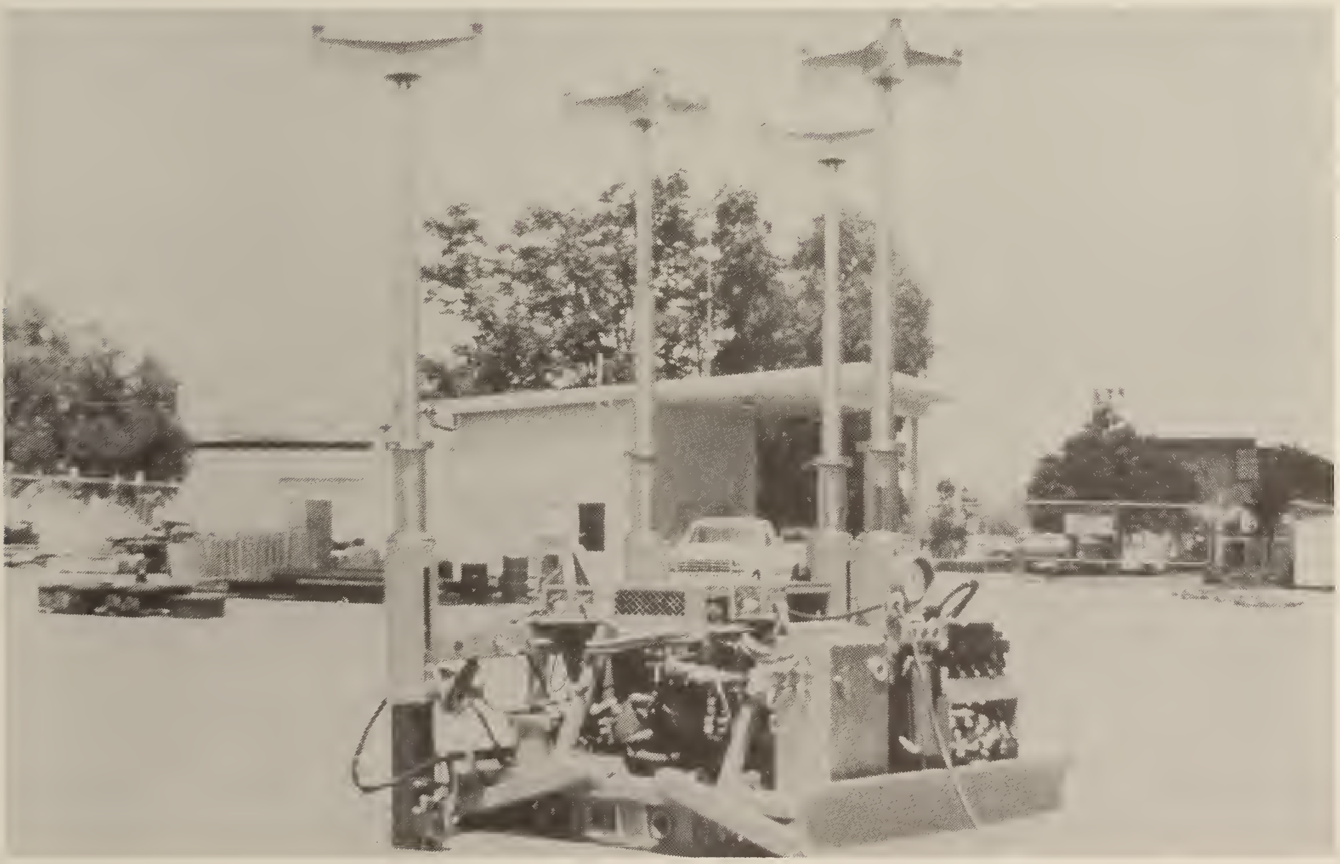

FIGURE 10. - Mobile roof support (MRS) prototype machine.

The other project called for the design, construction, and test of a mobile roof support (MRS), as shown in figure 10. This machine was tested underground at Inland Steel's Sesser Mine in Illinois. The four hydraulic jacks mounted on the battery-powered chassis are each capable of supporting 30 tons. There were a few problems with the prototype, but a second generation MRS has been built in conjunction with the Bureau of Mines and Southern Utah Fuel Co. Tests have not been completed.

ROOF SUPPORT SYSTEMS FOR FLETCHER ROOF DRILLS

By Douglas R. Hardman[1]

INTRODUCTION

The first automated temporary roof support system (ATRS) for a roof bolting machine was developed by J. H. Fletcher & Co. in mid-1971 and was delivered to a mine in November 1971. In 1972, a system was exhibited at the coal show in Cleveland, and several retrofit kits were developed. Since about mid-1973 most of our dual-head roof bolters have had a roof support system of some type.

Although we have some standard models of equipment, we also make custom-designed machines; therefore, we have several different ATRS configurations. While we have built a few ATRS systems that are attached to and move with the drilling unit, our main thrust has been toward systems that are independent of the drilling boom. This allows us to keep the worker under supported roof while maneuvering the drill head from the drilling controls. This paper covers roof supports on our different standard machines, custom-designed systems, single-head systems, and retrofits.

All of the roof support systems discussed in this paper conform to the West Virginia regulations for ATRS systems, but this does not necessarily mean they will comply with every mine roof support plan approved by MSHA. When a machine with a new ATRS is put into service, the mine operator must file a request for change to the roof support plan with MSHA. Over the past 10 to 12 yr we have worked very closely with roof support people at MSHA Technical Support and the local MSHA representatives. In all cases, their help and input have proved invaluable, and we have never had any problems in working out a viable solution.

TYPES OF FLETCHER ATRS SYSTEMS

Most of the machines we build are dual head, for which we have three main types of TRS systems: the H-style, the T-style, and the scissors style. The H-style, shown in figure 1, is used on our model DDM machines and is designed to elastically support a maximum load of 67,500 lb. The purpose of this type of system is to allow the operator to install two rows of bolts without having to reposition the machine.

The T-style TRS is shown in figure 2. This type of roof support is used on most of our dual-head machines with various mounting configurations, depending on the model of machine, mine conditions, and working height. Most of these T-style units sump and tilt to allow for a more compact package when tramming from place to place. These sump and tilt functions, along with features like front end lift and wagon brakes, are controlled from the inch-tram area as well as the tram deck.

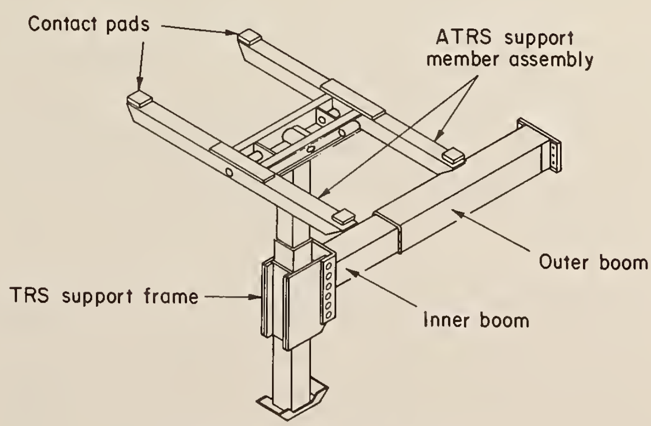

FIGURE 1. - H-style ATRS.

[1]Manager, Engineering Services, J. H. Fletcher & Co., Huntington, WV.

The scissors TRS shown in figure 3 is a variation of the T-style and was developed to gain increased versatility in low-seam operations. This system will collapse to a height of 30 in with 6 in of underclearance and extend to a maximum height of 8 ft if the need arises. A version of the scissors has also been built that will collapse to 24 in with a 60-in extension for operation in 29- to 30-in conditions. This type of system is best suited for mining heights below 4 ft. The 8-ft maximum height allows for excellent flexibility when conditions vary, but as the beam goes higher, the mechanics of the linkage cause it to rise at a slower rate.

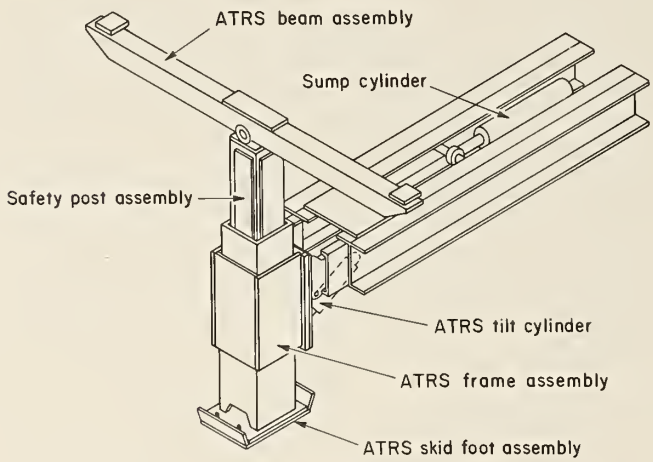

FIGURE 2. - T-style ATRS.

It also should be noted that the beam rises in an arc, which necessitates sumping the ATRS in and out for varying roof conditions. The beam and support structure for the T and scissors roof supports are designed to elastically support a load of 38,250 lb at a maximum width of 12 ft.

Most of our ATRS systems are supplied with adjustable rocker pads which allow the width of the support envelope to be varied in 6-in increments from 8 to 10 ft on one model and from 10 to 12 ft on another. All of these roof supports are actuated by hydraulic cylinders equipped with integral pilot-operated check valves which have a design pressure rating of 10,000 psi. The schematic in figure 4 shows that the circuit is designed to maintain thrust against the roof. When the control valve section is actuated to extend, the cylinder flow is directed to the V_2 port in the relief and check valve package. A built-in relief valve on the up-stroke side of the circuit allows the pressure setting on the system to be altered. Downstream from the relief valve there is a pilot-operated check valve in the line which acts to keep the accumulator charged. The accumulator usually has a capacity of 1 gal and is in the circuit to provide makeup oil to the system, which helps offset things like settling

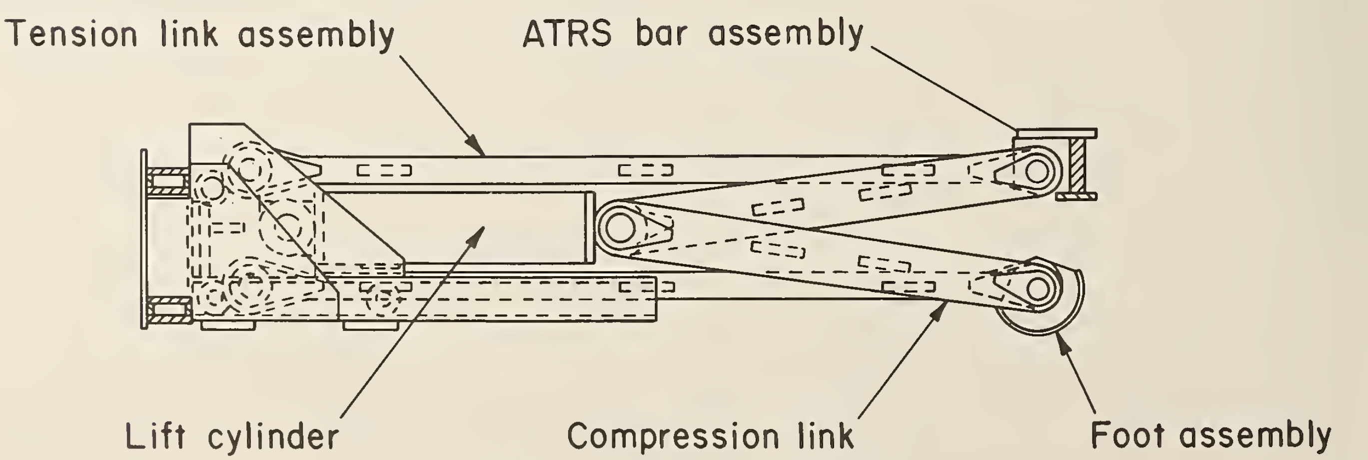

FIGURE 3. - Scissors support system.

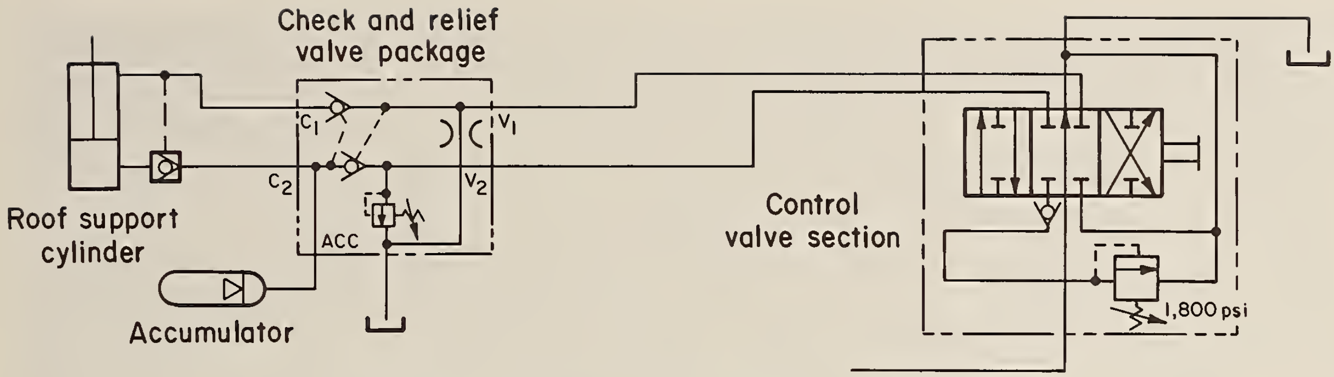

FIGURE 4. - Schematic of ATRS hydraulic system.

of the foot into the floor and minor leakage at the cylinder. In the package valve the return side of the cylinder is connected, through an orifice, to the main hydraulic tank. This lets oil out of the top of the cylinder when it is trying to readjust due to accumulator pressure.

DUAL-HEAD ROOF BOLTER MODELS

One of the standard dual-head machines built by Fletcher is the model DDM (figs. 5-6), which uses the H-style ATRS. This system allows the operator to install two rows of bolts with one machine setup. This is made possible by mounting the drill unit on a boom that swings 7 ft from the machine center line and sumps forward 9 ft. It is also possible to install a third row of bolts when the inby cross beam is within 5 ft of the face.

The ATRS controls for this machine are located in the tram deck along with controls for brakes, stab jacks, and boom swing. It should also be noted that each drilling unit is equipped with a safety post that can be considered part of the roof control system in some cases. Figure 6 shows an example of a special DDM with offset drilling units which was designed to provide operator protection in mines where bad rib conditions are a major concern. Machines of this type have been operating very effectively for years.

Figures 7 and 8 show two versions of a model DDO machine. There are quite a few different variations of this model, ranging from machines that will work in seam heights of 30 in to units that will operate in 8 ft of coal. All of these machines either use a T (fig. 7) or scissors (fig. 8) ATRS, depending on the height and operating conditions. The drill booms swing 9 ft from center and are equipped with 12-, 18-, or 24-in sumps. The positioning and ATRS controls are located over the left front wheel, and the unit must be moved after each row of bolts. In most cases a canopy is provided over the drill controls, but in some instances the canopy support cylinders have been approved as safety posts in lieu of canopies. In either case, as the operator moves from hole to hole installing a row of bolts parallel to the face, the main roof support system remains in place.

The DDR (fig. 9) is a relatively new model developed for areas where a mast-feed type of machine was requested. Different versions of this machine will operate in seam heights ranging from 5 to 12 ft. This model uses a T-style ATRS and in most cases incorporates either a canopy or a safety post at the drilling controls. The positioning and ATRS controls are located at the left front wheel, and the sequence of operation is the same as for model DDO.

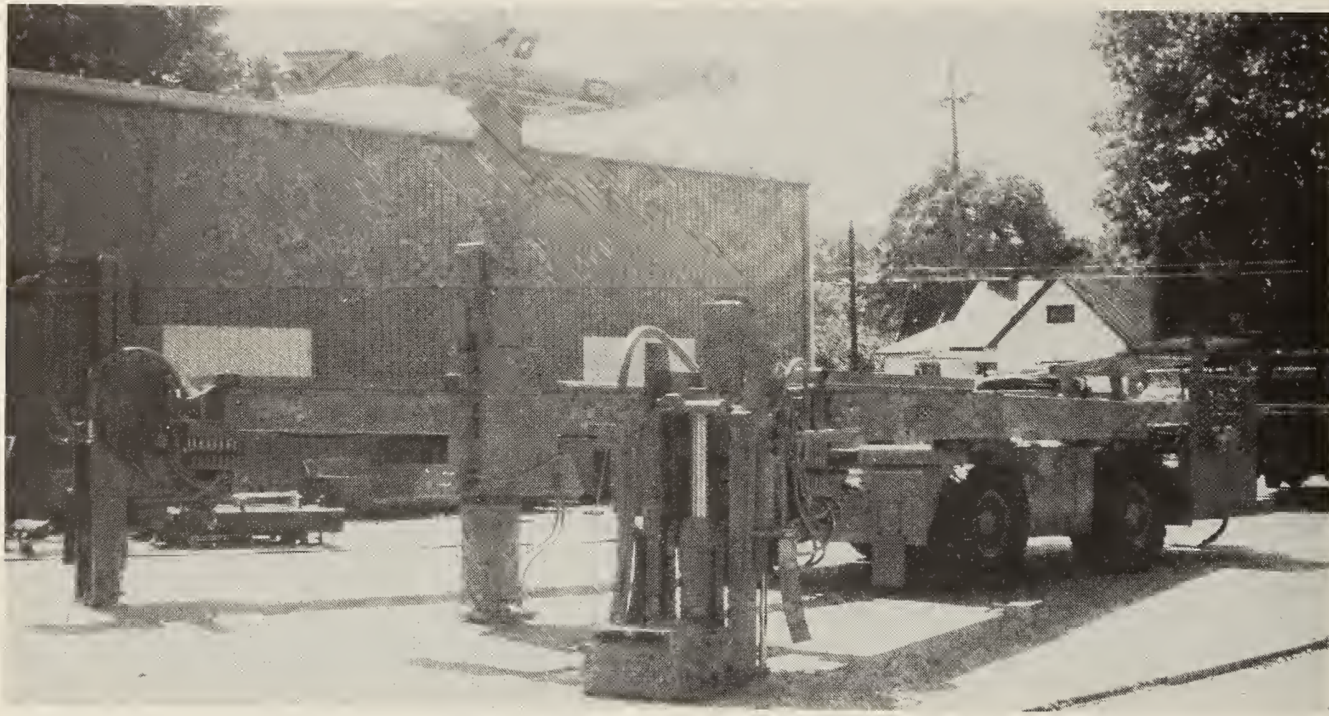

FIGURE 5. - Standard model DDM.

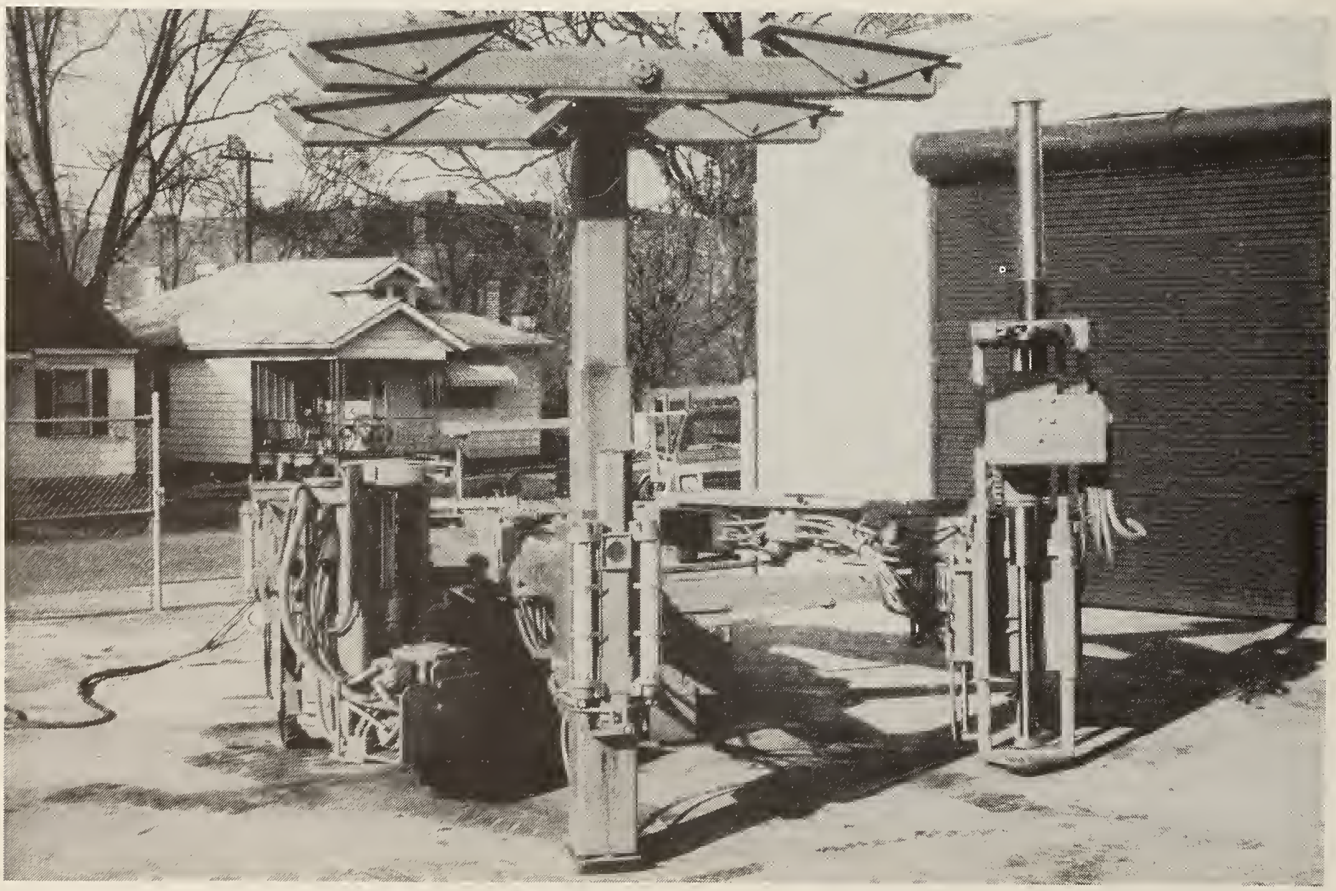

FIGURE 6. - Model DDM with offset drill controls.

FIGURE 7. - Model DDO with T-style ATRS.

FIGURE 8. - Model DDO with scissors-style ATRS.

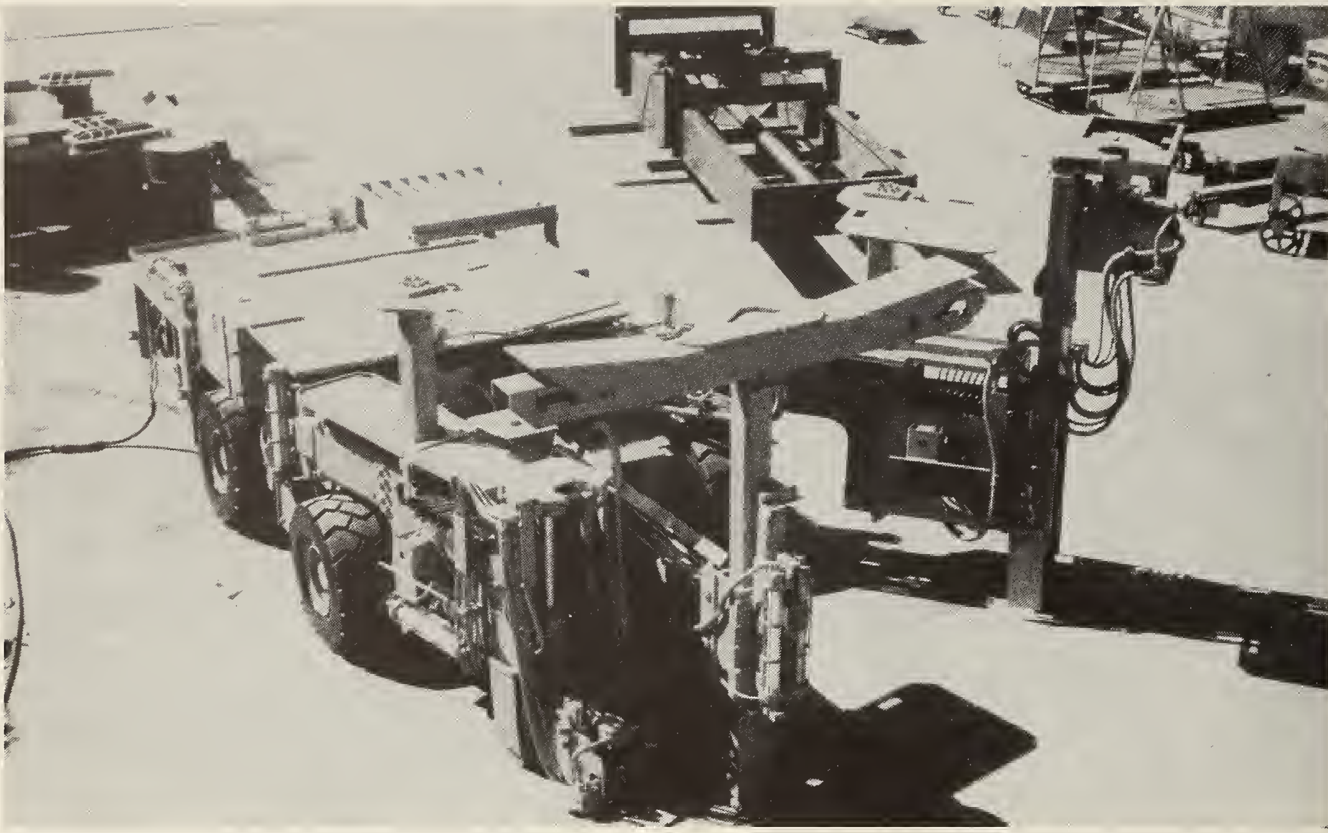

FIGURE 9. - Model DDR.

FIGURE 10. - Model HDDR with inside controls.

The model HDDR shown in figure 10 is an example of a very versatile machine designed for mines with high coal and bad rib conditions. This machine can install angle bolts and rib bolts as well as a conventional pattern. The drilling controls are in a basket that rises and moves with the drilling unit. The operator is under a canopy and is protected from rib falls by the boom structure. Figure 10 shows that the inch-tram and ATRS controls are located at the front of the machine and are accessible from either operator basket. In this situation the operator is not always under bolted roof when setting the ATRS but is under a canopy. Because of the bad rib conditions MSHA has approved this system, and we have several in operation in the Western States. These machines all have T-style ATRS systems which will operate in seam heights from 6 to 16 ft.

A new version of the DDR has just been developed to try a new approach to the problem of accessing inside controls. In this case there is a walkway through the middle of the machine which allows easy access to the front end and the inch-tram controls located behind the ATRS mounting point on the chassis.

At present Fletcher builds two models of dual-head machines that are primarily used to drill holes on an angle and install trusses. The DDJ shown in figure 11 uses a T-style ATRS in conjunction with canopies or safety posts near the drilling controls. The positioning and ATRS controls are located at the left front wheel along with controls for front and rear lift and wagon brakes. The drilling units and controls on this model move in a straight line parallel to the face, and one complete row of bolts may be installed with each machine setup. The DDJ can be designed for seam heights of 4 to 8 ft.

The LDDR shown in figure 12 is a relatively new design and is more versatile than the DDJ in that the booms sump and there is an extra swing function. This model uses a T- or scissors-style ATRS, and the chassis configuration is very similar to that of the DDJ and DDO. This model also utilizes a canopy or a safety post at the drill controls, and the sequence of operations is the same as for the other models with the T or scissors ATRS. A floating tram cab like the one on the LDDR in figure 12 is optional on all our dual-head bolters to allow for greater operator headroom in lower seams.

As can be seen from the previous discussion, the configuration of the drilling units on our dual-head machines varies drastically, but the roof support systems and the operating sequences are very similar on every model except the DDM and HDDR. The machine is trammed into the working place from the tram deck, which is located at the rear of the unit and covered by an approved canopy. The operator then actuates a diversion valve which shifts the flow of oil to the positioning or inch-tram controls. This prevents accidental actuation of the tram controls when the operator is at the front of the machine. The operator then proceeds to the positioning station and moves the machine into final position for installing the first row of bolts. It should be noted that at this point the operator is still under bolted roof. At this time the operator sets the ATRS, throws another diversion valve which sends the flow of oil to the drilling controls, and moves forward to position the drill head and install the first bolt.

The drilling unit swings at least 9 ft and sumps at least 12 in, which allows the operator to precisely pinpoint each bolt location in the row without disturbing the roof support system. For special bolt patterns the sump and swing may be increased and the width of the roof support system varied accordingly.

Retrofit of ATRS systems to Fletcher dual-head machines is not a major problem, and at this time most of the models built without roof supports have had systems designed for them. The principle is the same as already discussed for most

FIGURE 11. - Model DDJ with T-style ATRS.

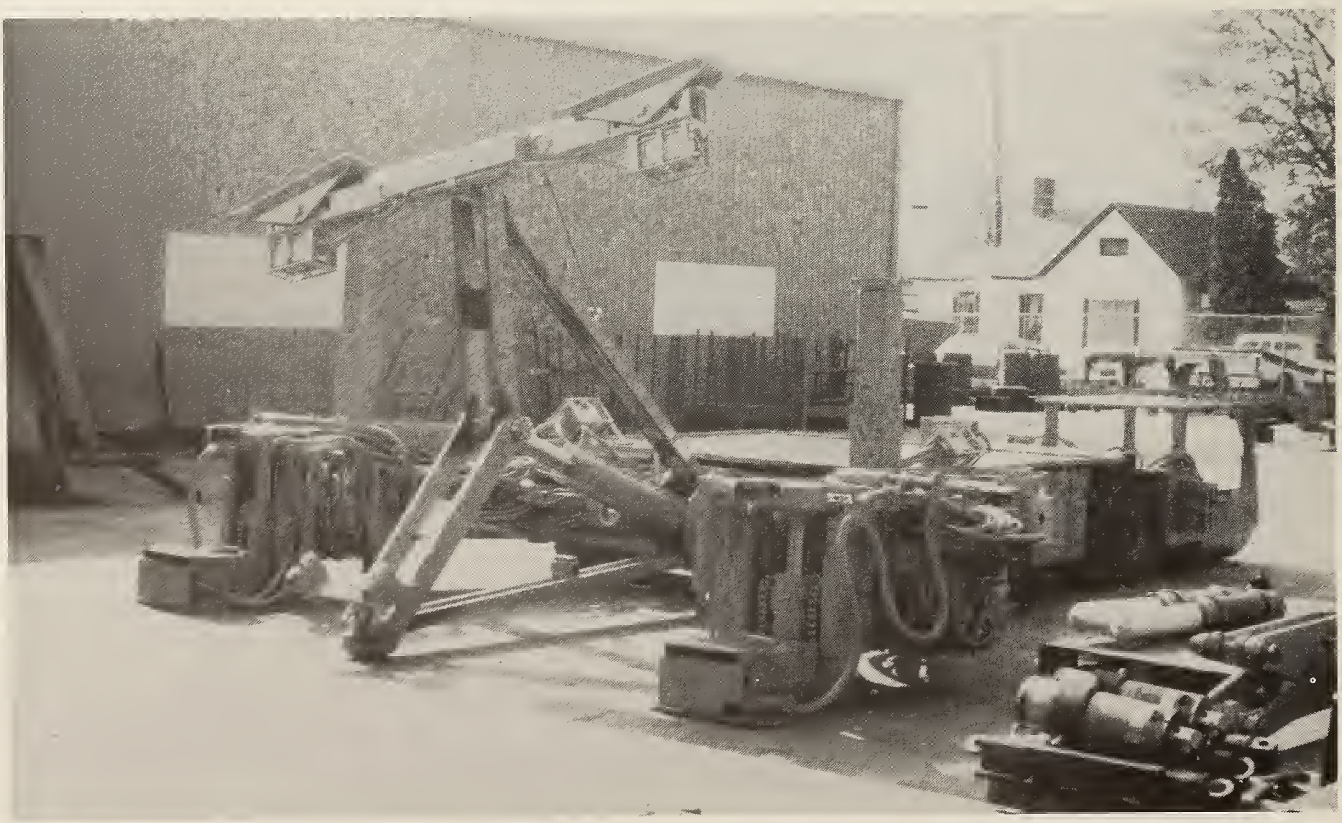

FIGURE 12. - Model LDDR with scissors-style ATRS and floating tram cab.

models; in most cases the only problem has been developing mounting brackets for some of the custom-designed units built in the late 1960's. As was stated in the beginning of this paper, almost all dual-head machines built since mid-1973 were shipped with a roof support system of some type.

Although our main thrust is to isolate the ATRS from the drilling unit, we have built a few units with other systems. Figure 13 shows a DDM with a crows-foot roof support. On this unit no inch tram is required because the boom will sump 9 ft. A valve was mounted on the boom about 5 ft behind the drillng controls; from this point, the operator controls the roof suport and repositions the drilling unit while remaining under bolted roof.

Figure 14 shows a DDO with a ring-style ATRS. Both of these types of roof supports conform to the law, but there are two major problems. First, it is very hard to position the drillhead with any degree of accuracy, and often it takes more than one try, which can be time consuming in a production cycle. Second, and most important, is the fact that when the boom is being moved there is no support at all in contact with the roof. The beam system is always in contact with the roof when the man is at the drilling controls, and this extra edge has proved to be valuable.

SINGLE-HEAD ROOF BOLTER MODELS

For our single-head machines we have two types of ATRS systems--the crows foot and the arm style with rocker pads. Figure 15 shows a crows foot roof support in relation to the drill head on a mast feed style machine, and figure 16 shows a layout of a crows foot with a ring. The configuration of this type of system varies depending on the machine model, the mine roof conditions, and customer input. The design load rating depends on the support envelope, but in most cases it works out to around 11,250 lb. If this type of support is used in lieu of canopies, the arms must project at least 18 in in front of the drill head. The crows foot is mounted on either a single or double extending cylinder enclosed in a shroud of telescoping square tubing, and the hydraulic circuit is the same as shown in figure 4. As mentioned before, this system is attached to and moves with the drill unit, which can cause problems.

The arm-type system of roof support is used on our new model LTDO shown in figure 17. The arms move independently of each other and are tied together only in that the two hydraulic cylinders are operated by the same valve section. This feature, along with the rocker pads, allows for maximum surface contact in uneven roof. This system will also work with a ring, but some degree of flexibility will be sacrificed by tying the arms together. In almost all cases, both the arm-style and the crows-foot roof supports are made of a high-strength alloy steel with a minimum yield of 100,000 psi to achieve a reasonable weight-to-strength ratio. The drilling unit of the LTDO is independent of the arms, and it is able to sump 8 in and swing 3 in to each side of center. This feature allows for accurate bolt location without disturbing the roof support. The LTDO in figure 18 also has a canopy incorporated into the rocker of the ATRS.

The model DB machine is different from the LTDO only in that it uses a mast feed for the drill head instead of an arm feed and a crows-foot rather than an arm-type ATRS. Both the LTDO and DB have the inch-tram and ATRS controls between the wheels and a tram deck with canopy at the rear of the machine. In both cases, either a stab jack or stab foot is included and is considered a part of the support system. A floating tram cab for low seams is also available on model LTDO and DB machines.

To date, we have not built a single-head machine that can install more than one bolt on a regular pattern with a

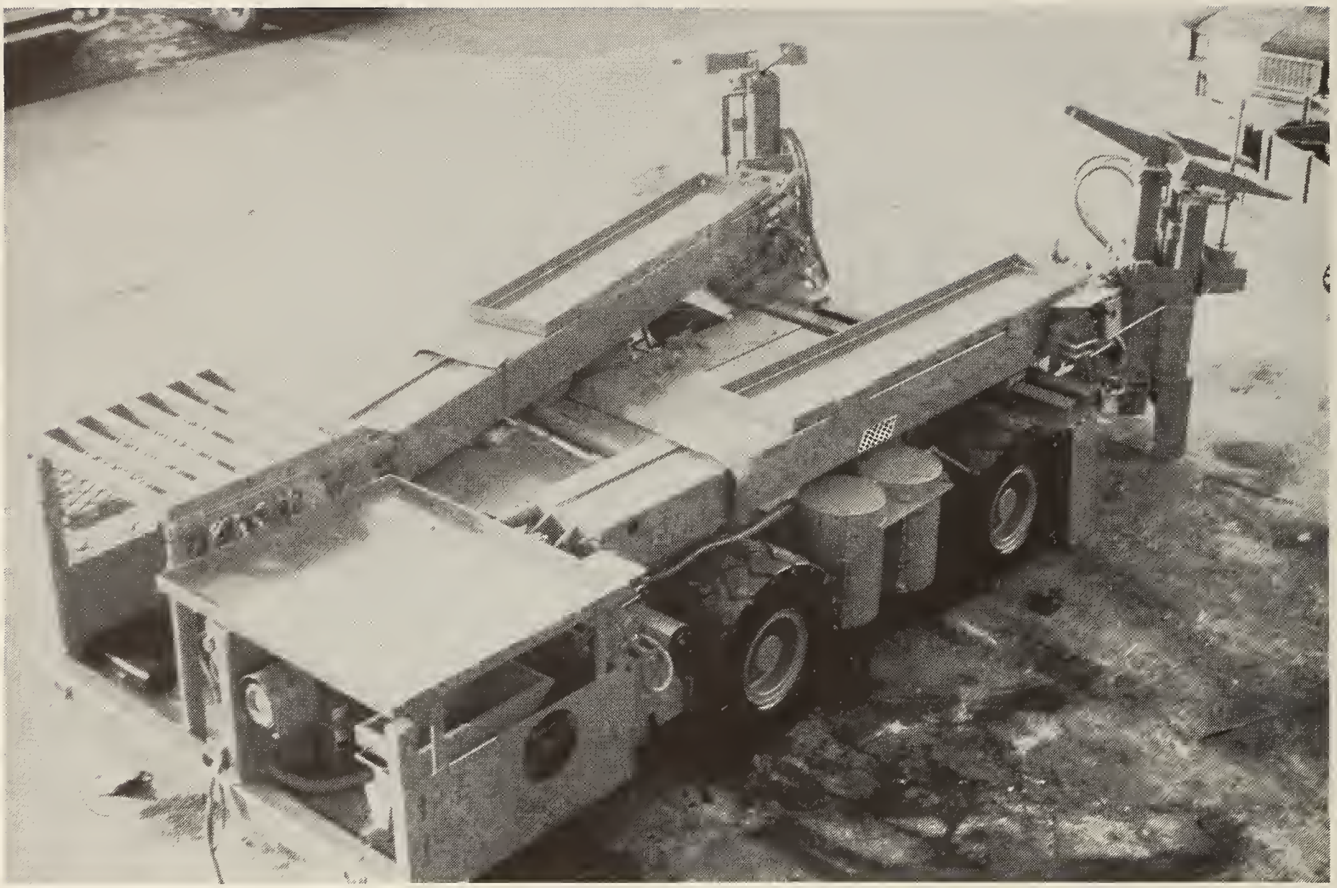

FIGURE 13. - Model DDM with crows-foot ATRS.

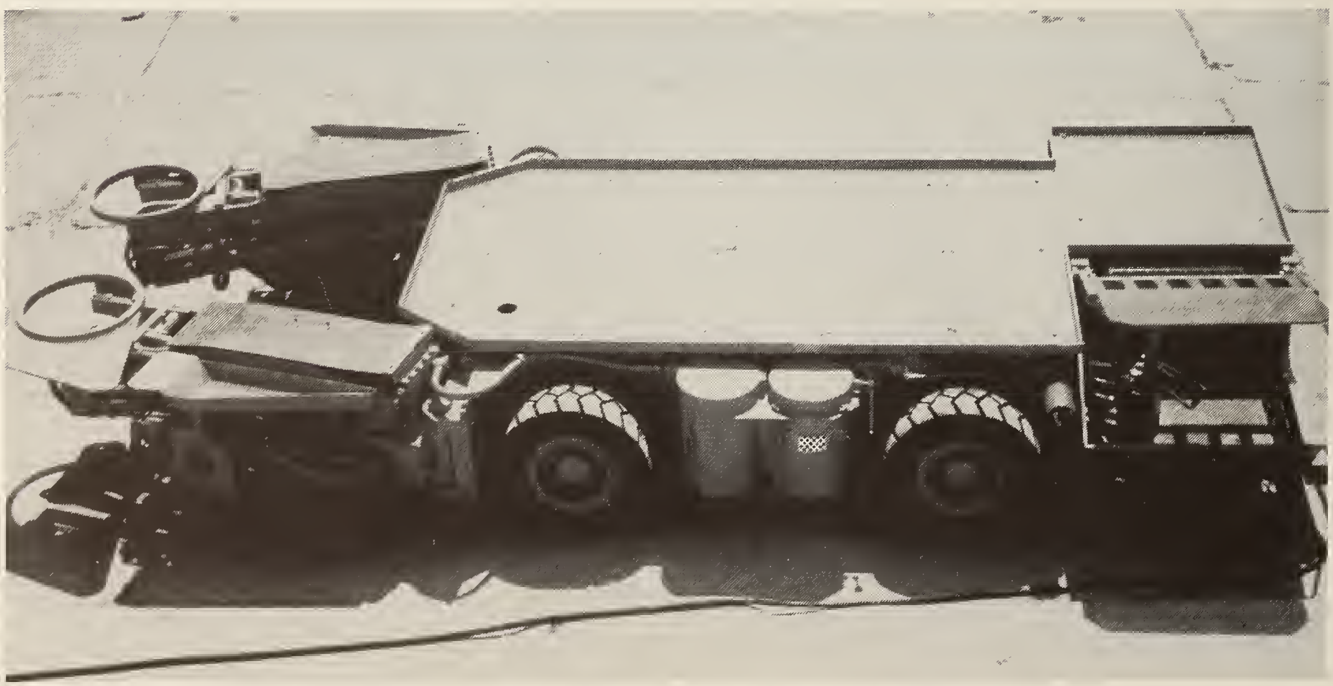

FIGURE 14. - Model DDO with ring-style ATRS.

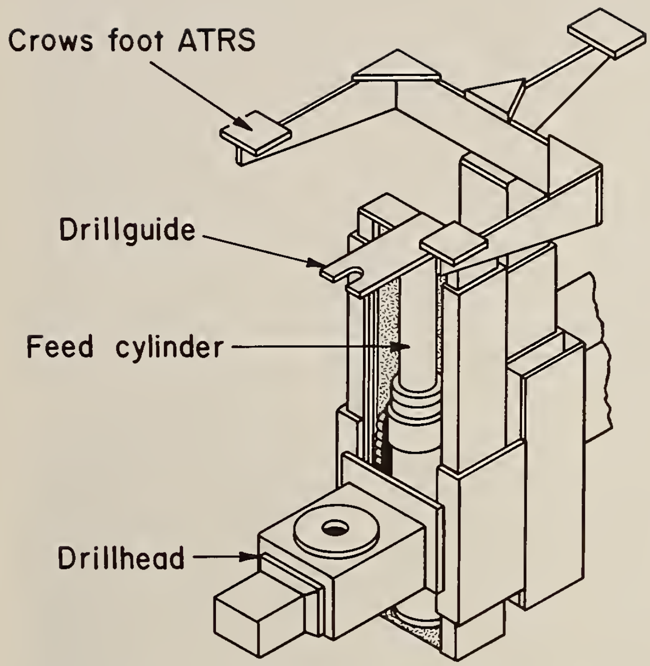

FIGURE 15. - Crows-foot ATRS on drill mast.

single ATRS setup; however, we have designed a few single-head machines that could do this. In most cases a dual-head machine is much more practical from a cost benefit standpoint than a single-head unit, and for this reason, we have not emphasized the single-head, multiple-bolt machine.

Retrofit kits have been developed for most of our single-head units using either a crows-foot or an arm-style ATRS. Since most of these old machines do not have swinging or sumping booms, the roof support and the drill head are usually not independent of each other. Another factor that must be taken into consideration on older machines is tram canopies. Most of these machines did not have tram decks at the rear when they were originally built, so a tram canopy must be added to comply with MSHA requirements when they are modified. Fletcher has developed a few kits for some of our LTDO's

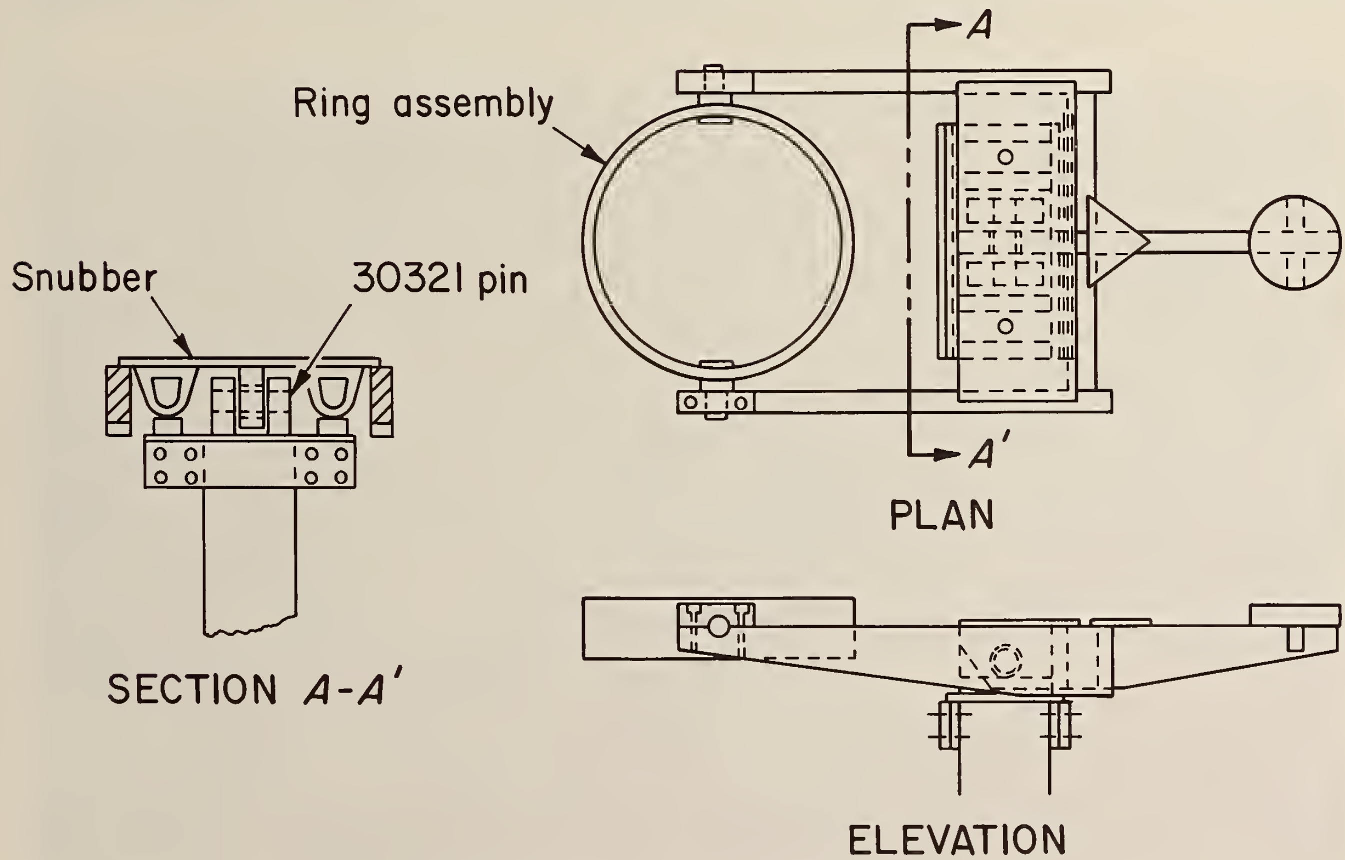

FIGURE 16. - Crows-foot ATRS with ring.

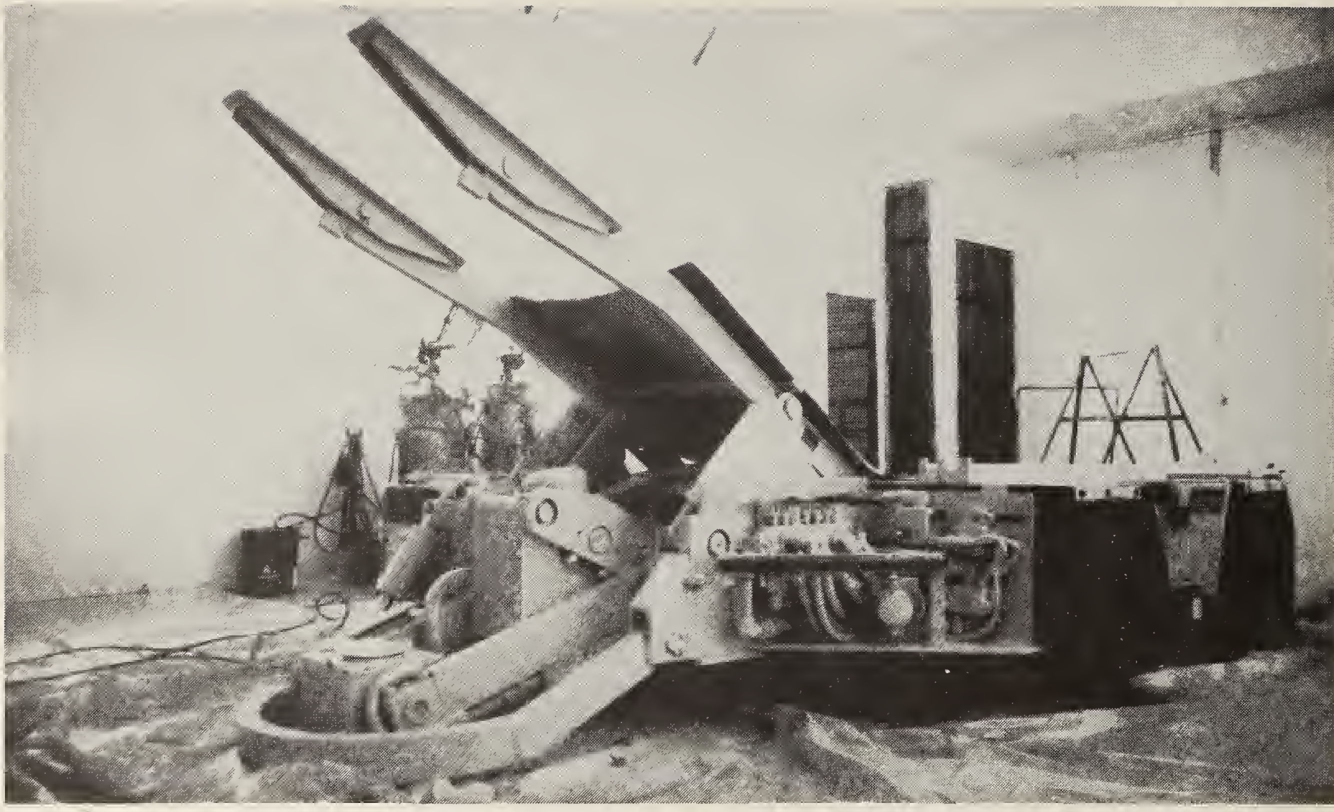

FIGURE 17. - Model LTDO with arm-style ATRS.

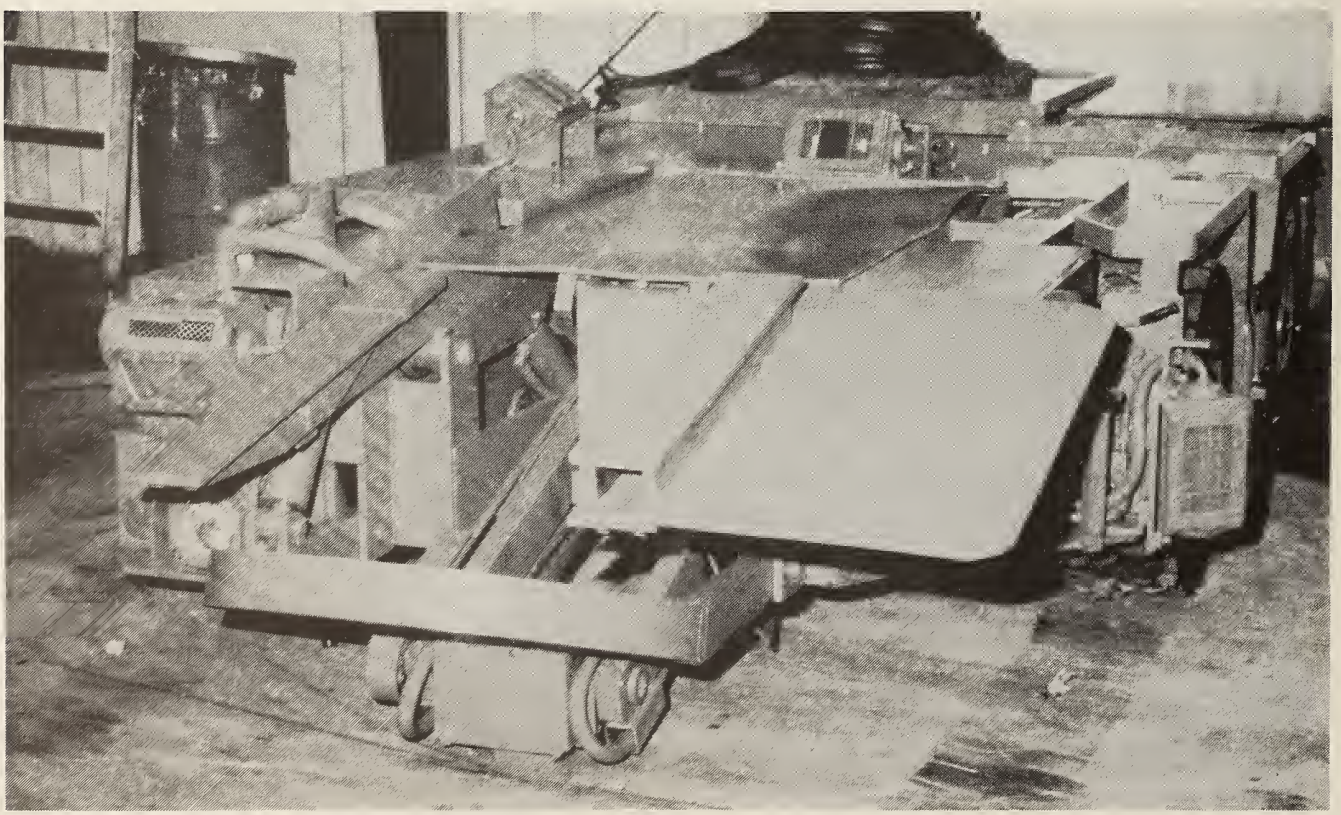

FIGURE 18. - Model LTDO with drilling canopy on ATRS rocker pad.

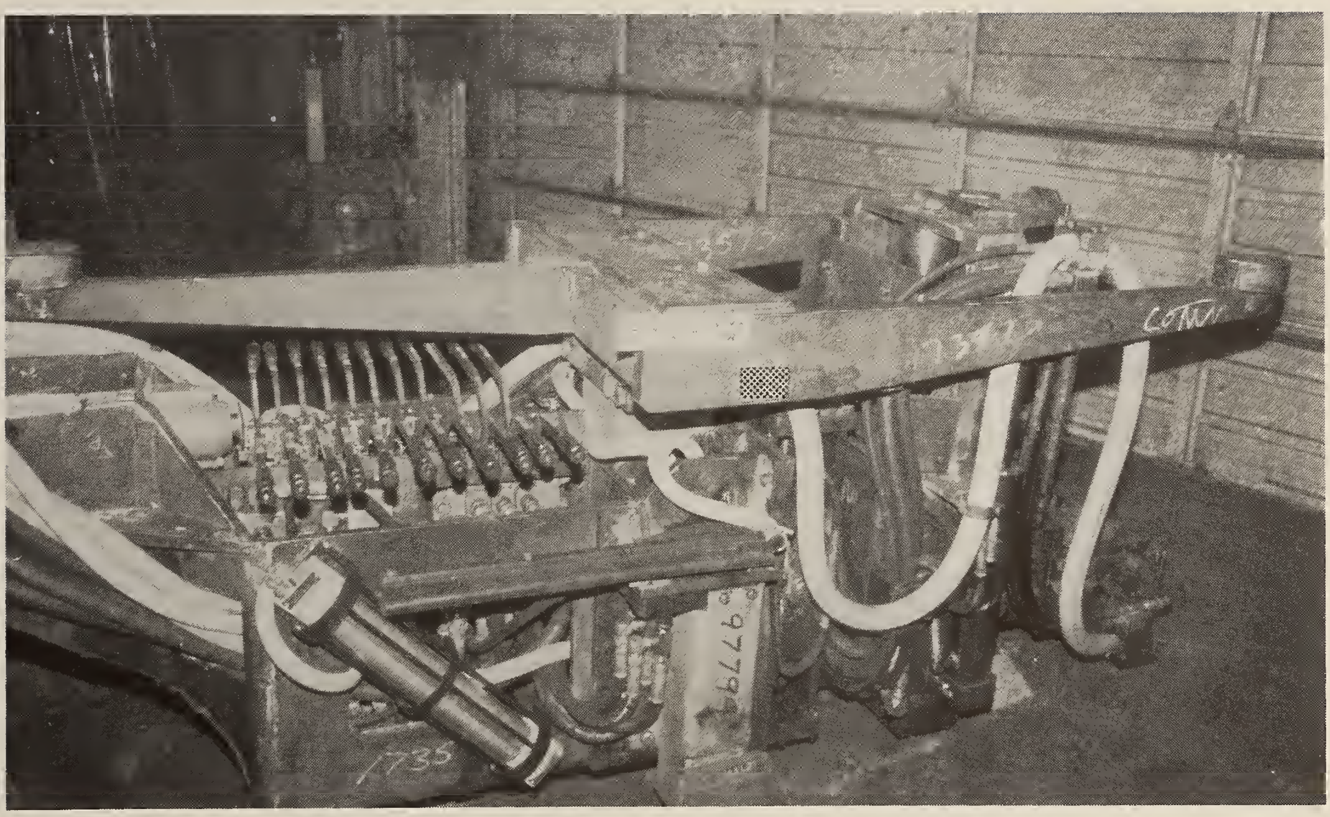

FIGURE 19. - Model DB with retrofitted crows-foot ATRS.

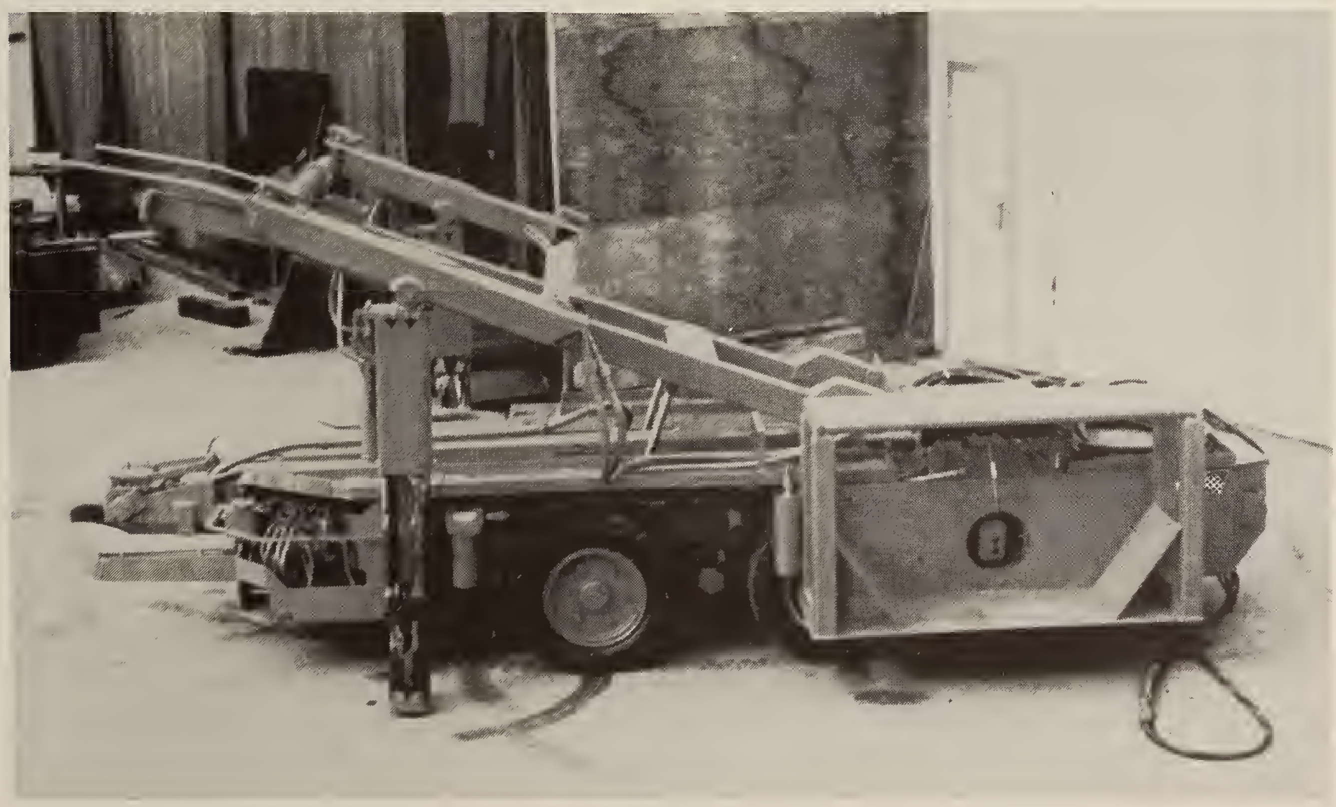

FIGURE 20. - Stand-alone or satellite ATRS system on a model DO.

and DB's, but the cost and time involved were excessive and in the end we had a machine that was too cumbersome to be practical in a production cycle. It also should be remembered that most of the frames and drive systems on these old units were not designed to carry the increased weight encountered when adding a roof support and tram deck. A crows-foot ATRS can be added fairly easily to a machine that already has a rear tram deck, but reduced flexibility makes it very hard to use a machine of this type in a production cycle. Figure 19 is an example of a retrofit of a crows foot on a model DB drill.

We tried a stand-alone, or satellite, ATRS system on a single-head model DO roof drill (fig. 20) in 1973 but set the concept aside because we felt that the possibilty of knocking the support posts out with the machine was too great. The ATRS unit contained two cross members; unlike satellite systems developed by others, our ATRS was carried with a pair of extra lifting arms instead of the drill head.

RETROFIT AND REBUILD PROCEDURES

After careful consideration and some cost studies of existing retrofit projects, we feel that in many cases the most practical thing to do is salvage the parts and install them on a new chassis, with a rear tram deck and an arm-style ATRS. Many of the components such as wheel hubs, drive motors, drill heads, and valves can be reused, and in most cases all of the cylinders and electrical components will adapt. In all cases a new chassis would be designed to adapt to as many of the old components as possible, and the drill unit would be installed on a boom that swings and sumps. We feel that this can be done for a relatively small additional cost, and in the end the customer will have a machine that is much more practical from a production standpoint. Increased productivity could very well offset the increased cost of the new chassis and boom.

This may not be the best solution, however, if the machine is going to be used only for utility bolting. Since the location of the bolt will not be critical, a crows-foot kit or a good canopy may be the best solution. Each situation must be studied, and the best solution will depend on how the machine is going to be used, the conditions in which it will be required to operate, and the overall condition of the machine in question.

ATRS SYSTEMS FOR LEE-NORSE ROOF BOLTERS

By Guido Bucelluni[1]

INTRODUCTION

Several of the papers presented earlier in this meeting discussed the technical aspects of ATRS systems in general and the requirements of existing ATRS regulations. Therefore, this paper will discuss only Lee-Norse bolting machines and the ATRS systems designed for them.

GENERAL FEATURES

All ring-type or support-arm ATRS systems for Lee-Norse bolters contain all design features needed to meet ATRS and "in lieu of canopy" regulations (pilot check valves, streamlined controls, load-carrying capability, etc.). The configuration of the roof support ring on Lee-Norse bolters can vary from round to hexagonal to rectangular, but all such structures extend 6 in inby the drill chuck. The support arm hydraulic system is designed to automatically maintain a factory-determined upward thrust of 1,500 to 2,000 lb on the roof support structure. Most Lee-Norse bolter models contain a sumping drill box (8-in range of travel) to compensate for drill chuck misalignment when the support arm is in place. This feature allows the operator to locate the drill hole precisely without moving the entire ATRS system. All design features of the support-arm system can be retrofitted to machines in the field.

Although the support arm ATRS system alone is sufficient to meet all ATRS requirements, some customers also desire the additional protection of an out-front, bar-type ATRS structure. For this reason, Lee-Norse offers two types of bar-type structures, the dolly-bar and the T-bar designs, as optional or retrofit equipment on all dual-head bolters. The dolly bar has a collapsed height of 23 in and requires 4 to 7 s to reach its maximum extended height of 93 in. The T-bar has a more limited height range (51 in to 10 ft), but has a sump range of 54 in. When the sumping jack is fully retracted, the T-bar fits easily between the support arms of the dual-boom bolter.

SINGLE-HEAD BOLTERS

Figure 1 shows the TD1-24/27 model roof bolter (frame height 24 to 27 in), and figure 2 shows the TD1-29/31 model (frame height 29 to 31 in). Both models contain support-arm ATRS systems with streamlined inch-tram stations. One major difference between the two models is that the TD1-29/31 has a cantilevered, "elephant ear" canopy over the drilling-bolting station, whereas the TD1-24/27 does not. The other major difference is that the tramming deck and canopy are located on the left rear corner of the TD1-29/31; on the TD1-24/27 these items are located farther forward, adjacent to the left tram wheels.

[1]Product manager, roof bolters, Lee-Norse Co., Pittsburgh, PA.

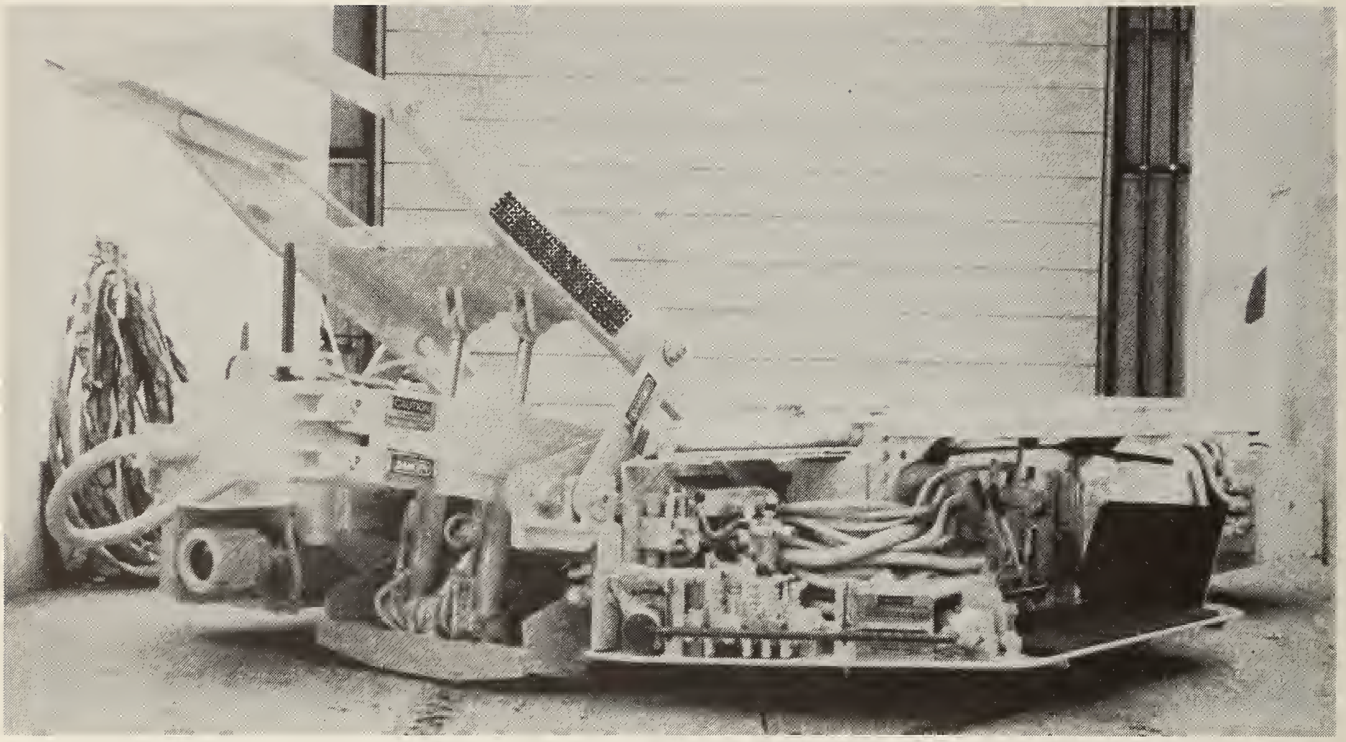

FIGURE 1. - Low-coal, single-head, TD1-24/27 roof bolter with safety-arm ATRS.

DUAL-HEAD BOLTERS

Lee-Norse manufactures three basic models of dual-head roof bolters--the TD2-30/34 (figs. 3-4), the TD2-43 (figs. 5-6), and the TD-12 (fig. 7). Figure 3 shows the TD2-30/34 with support arms only; figure 4 shows the same machine with a dolly-bar ATRS system in addition to the support arms. Note in figure 3 that the tramming deck and canopy are located between the tires on the right side of the machine.

The TD2-43 (figs. 5-6) is a slightly larger machine (support arms reach 10 ft high), but its tram station is basically the same as the one on the TD2-30/34. The major differences between the machines in figures 5 and 6 are (1) the TD2-43 in figure 5 has round roof support rings and a dolly-bar ATRS beam and (2) the TD2-43 in figure 6 has rectangular roof support rings and a T-bar ATRS beam.

Figure 7 shows the mast-type TD-12 bolter, designed for situations where angle bolting is required (roof trusses, rib bolts, etc.). When used for vertical drilling, the posts and canopies above the drilling-bolting stations are sufficient to meet all applicable regulations; the out-front dolly bar is an optional feature. Since truss and rib bolts are usually installed under supported roof, only canopy laws apply, so the TD-12 machine is sufficient for this purpose. The out-front dolly bar (or T-bar) may be required if angle drilling is conducted in areas of unsupported roof.

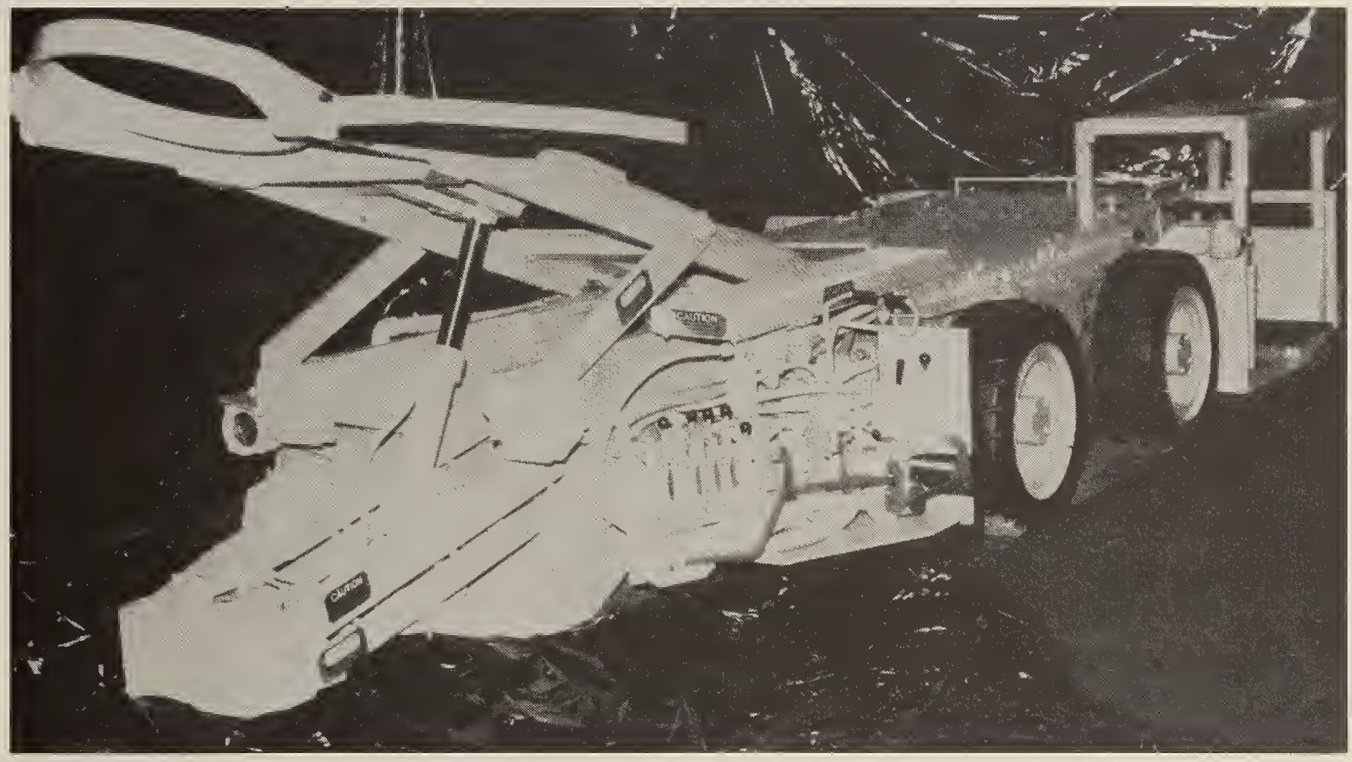

FIGURE 2. - Single-head TD1-29/31 roof bolter with safety-arm ATRS and cantilevered drilling canopy.

FIGURE 3. - Dual-head TD2-30/34 roof bolter with safety-arm ATRS.

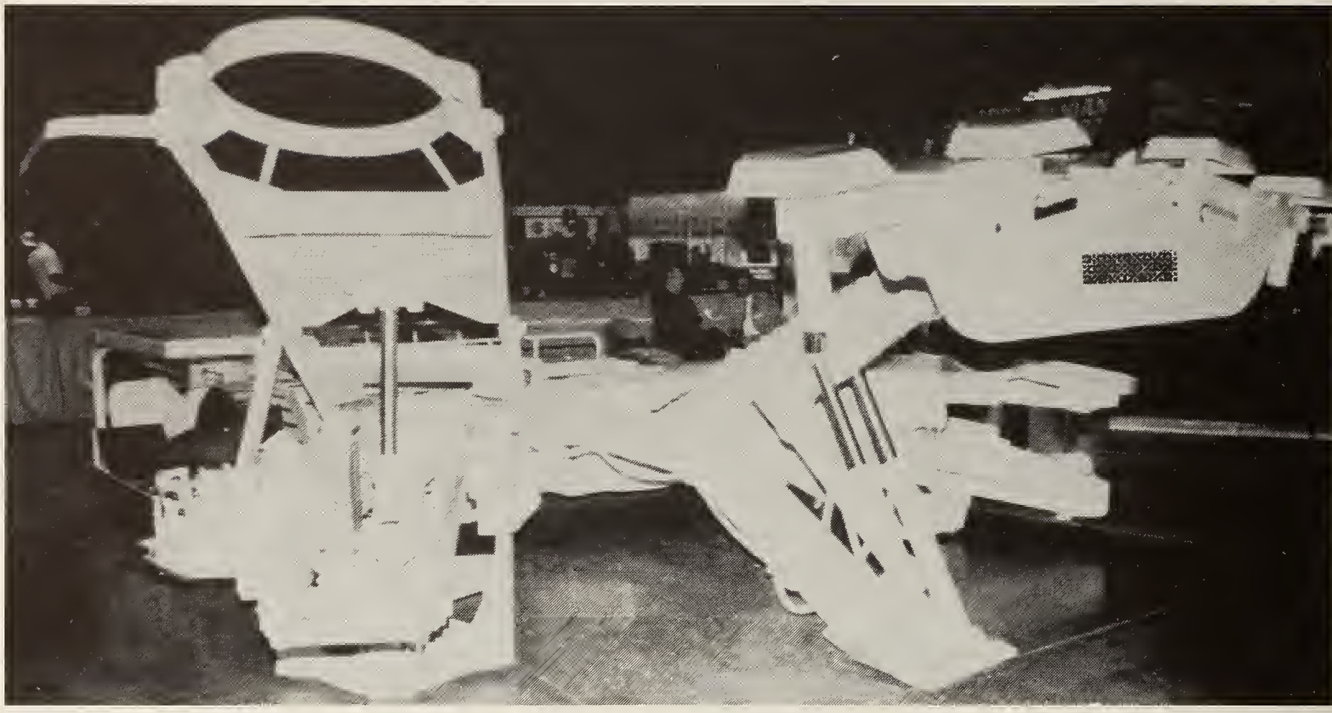

FIGURE 4. - TD2-30/34 roof bolter with dolly-bar and safety-arm ATRS.

FIGURE 5. - Dual-head TD2-43 roof bolter with dolly-bar ATRS.

FIGURE 6. - TD2-43 roof bolter with T-bar ATRS.

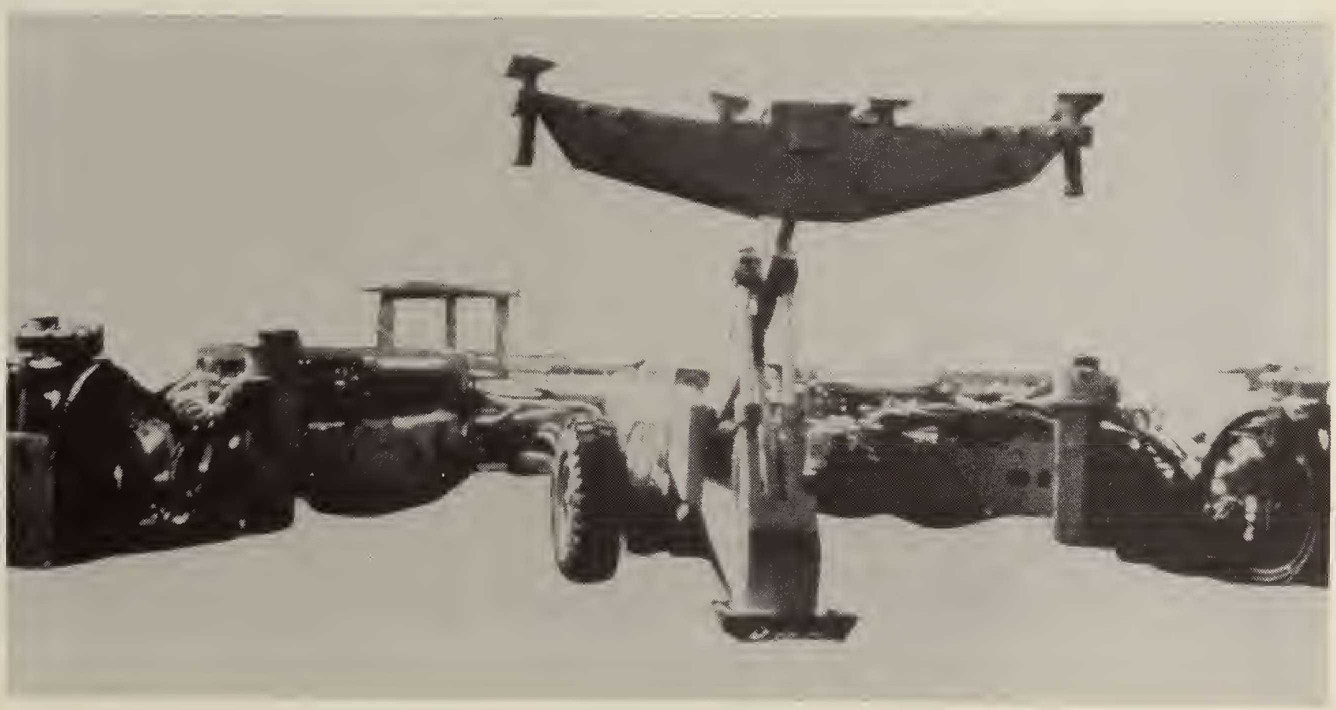

FIGURE 7. - Mast-type TD-12 roof bolter for angle bolting.

LONG-AIRDOX ATRS SYSTEMS FOR ROOF BOLTERS

By C. L. Bandy, Jr.,[1] and David L. Phillips[2]

INTRODUCTION

Long-Airdox Co. has been a manufacturer of roof bolting machines for over 20 yr. In view of this, it is easy to understand that Long-Airdox has a vested interest in safety systems for roof bolting machines. Subsequently, a series of ATRS systems have been developed and integrated into their product lines.

Although presently West Virginia and Virginia are the only States to mandate the use of ATRS systems, Long-Airdox feels that such systems used on bolting machines are effective tools for protecting miners during the installation of permanent supports. Together with providing protection for miners, substantial time savings in bolter turnaround time have been realized, thus enhancing their use.

[1]Director, field service training, Long-Airdox Co., Oak Hill, WV.
[2]Project engineer, roof bolters, Long-Airdox Co., Oak Hill, WV.

NEW MACHINE DESIGNS

Long-Airdox Co. offers a wide range of roof bolting machines to work in low, medium, and high seams.

LRB-25 For Low Seams

Figure 1 shows an LRB-25 roof bolter designed for low-seam operation. As shown, the LRB-25 is equipped with a mast-type ATRS with a single-beam load frame. The ATRS load certification is for 22,500 lb. The ATRS has a hydraulically actuated stroke of 12 in with a nominal base specified from 22 to 34 in. Overall height may be adjusted upward (in 2-in increments) an additional 6 in. As shown in figure 1, the ATRS remains attached to the bolter and can be raised up with 5 in of ground clearance and remain 22 in in overall height. Once the ATRS is set, it acts as a stabilizer, thus permitting the bolter to be backed away approximately 14 in, allowing clear

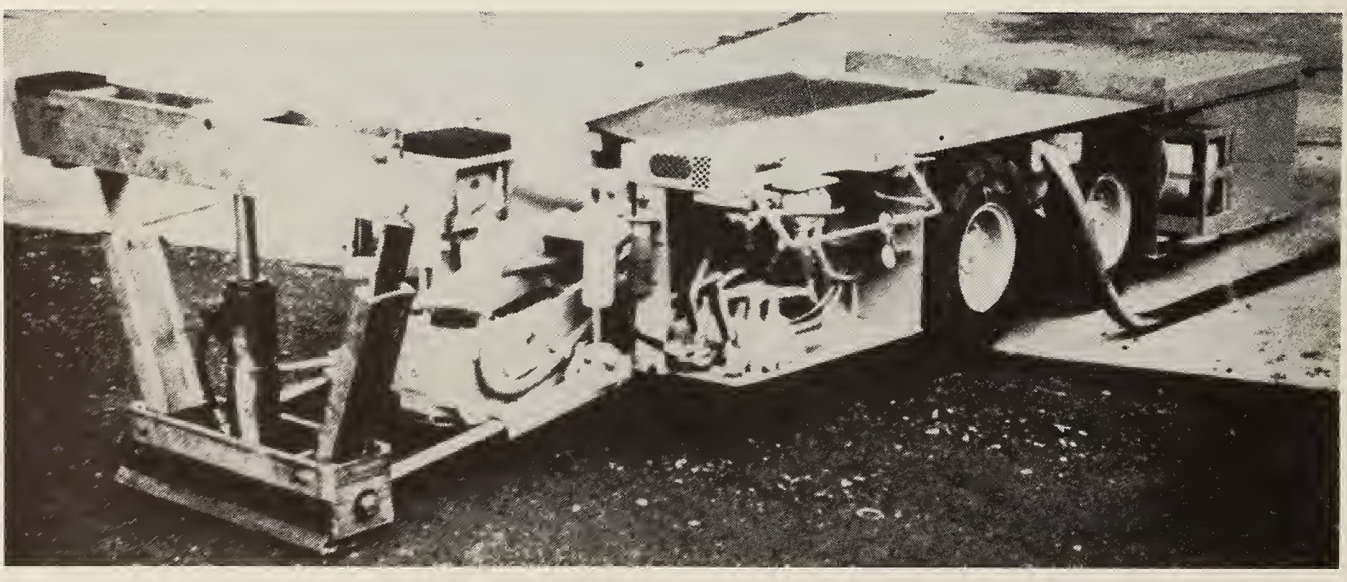

FIGURE 1. - LRB-25 for low seam with single-beam mast-type ATRS.

access for installing bent bolts. The LRB-25 measures 24 in high (with 4-in ground clearance) by 44 in wide by 11 ft 9 in long and weighs 4,400 lb.

LRB-15AR For Low to Medium Seams

Figure 2 shows a model LRB-15AR roof bolter equipped with a safety-arm-type ATRS. The ATRS ranges from 30 in minimum to 76-5/8 in maximum (6-in ground clearance) and is load certified at 11,250 lb. Maximum range is 82-5/8 in with 12-in ground clearance. An opening measuring 21 in wide by 32 in long is provided in the ATRS for ease of bolting. The LRB-15AR measures 27 in high by 74 in wide by 14 ft 10 in long (with 6-in ground clearance) and weighs 12,000 lb.

LRB-16 for Medium to High Seams

Figure 3 illustrates the LRB-16 roof bolter, which is furnished with a single-safety-arm type ATRS. The ATRS ranges from 50-1/2 in mimimum to 120 in maximum (with 18-in ground clearance) and is load certified at 11,250 lb. Minimum range is 42-1/2 in with 10-in ground clearance. An opening is provided in the ATRS head measuring 27-1/2 in by 30 in to ease the bolting operation. The LRB-16 overall dimensions are 50 in high (18-in ground clearance) by 80-1/2 in wide by 19 ft 4 in long, and it weighs 18,200 lb.

LRB-23 for Medium to High Seams

Figure 4 pictures a Long-Airdox LRB-23 dual-arm roof bolting machine with a mast-type H-beam load frame ATRS certified at 67,500 lb. This model is also available with a mast-type ATRS with single-beam load frame certified at 33,750 lb. ATRS range is specified from 48 in minimum to 14 ft 0 in maximum. ATRS width is adjustable from 8 ft 0 in to 10 ft 0 in. The ATRS is provided with a 7 ft 0 in nominal sump, thus allowing for two rows of bolts using standard centers. The H-beam ATRS design provides 5 ft 0 in between load frames. Basic machine dimensions for the LRB-23 are 48 in high (12 in ground clearance) by 9 ft 2 in wide by 20 ft 4-3/8 in long. Weight is approximately 46,100 lb.

FIGURE 2. - LRB-15AR with safety-arm ATRS.

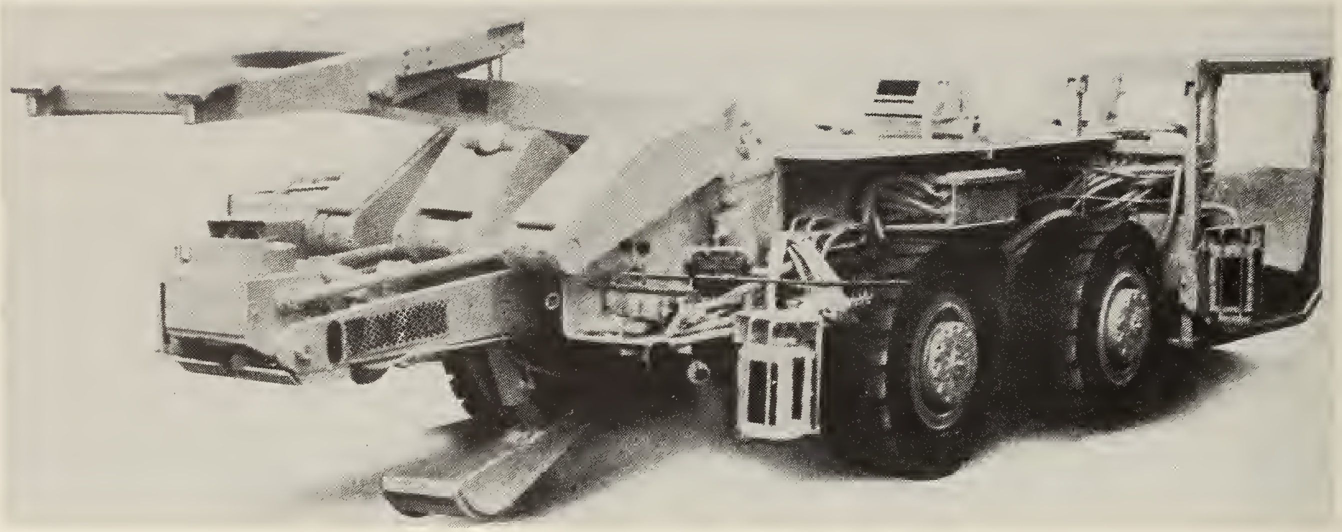

FIGURE 3. - LRB-16 with safety-arm ATRS.

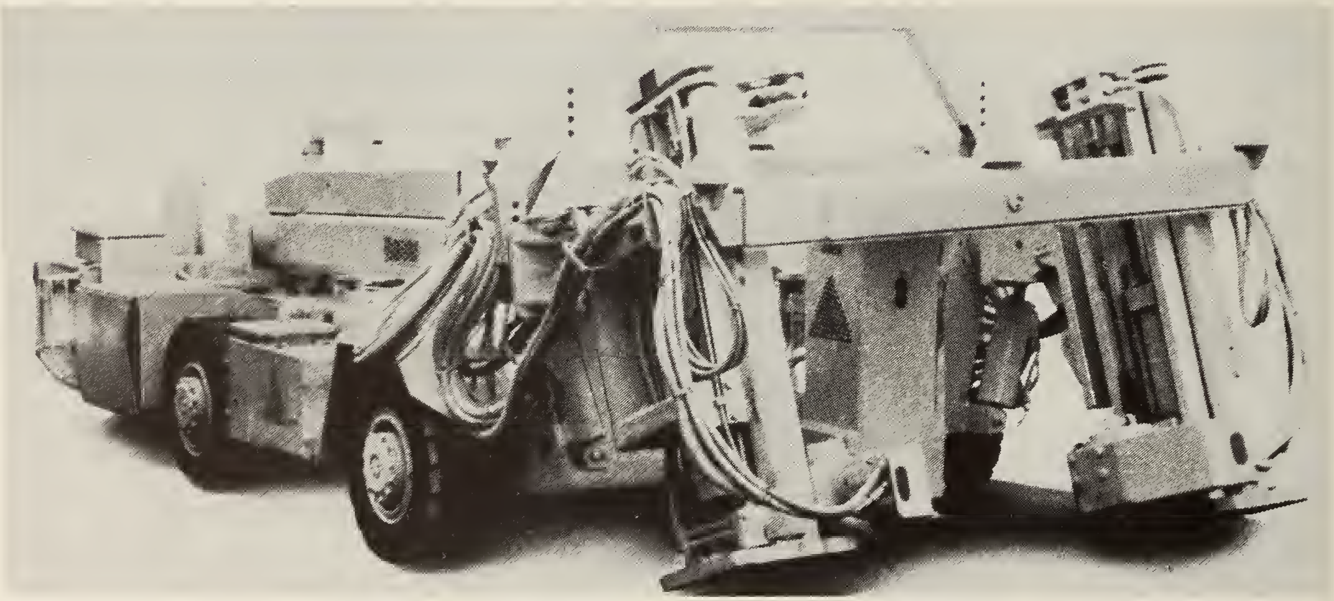

FIGURE 4. - LRB-23 with mast-type H-beam ATRS.

RETROFITTING

Along with designing ATRS systems for new roof bolting machines, Long-Airdox has an ongoing program of design to fit existing units with ATRS systems. Two existing Long-Airdox roof bolters (LRB-15 and LRB-15A) have conversion kits available from the factory, as follows:

<u>LRB-15A conversion to safety-arm-type ARTS</u>

1. Complete inch-tram system.

2. Relocation of ATRS controls to a point where they will be under permanently supported roof during setup.

3. Complete ATRS system as per LRB-15AR design (not mandatory if unit was equipped from factory with roof support system).

LRB-15 conversion to mast-type H-beam load frame ATRS

1. Relocation of tram compartment from front to rear of unit.

2. General rearrangement of internal components.

3. Complete inch-tram system.

4. Unit is fitted with a mast-type ATRS. Some units were originally supplied with a canopy from the factory. If so, this canopy is removed and bolter is then fitted with ATRS.

5. ATRS controls are located where they will be under permanently supported roof during setup.

CONCLUSION

Since the early 1960's, Long-Airdox has been actively engaged in the design of roof bolting machines. Functional ATRS systems have evolved and been accepted as viable protective devices for mine personnel during the bolting operation.

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